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March 2002

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Right-to-left: Meade 8", 10", and 12" LX200GPS Schmidt-Cassegrain telescopes. Manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.

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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment.

Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager — systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

Autostar II: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 125,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

Library	No. of Objects
New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28, 484
SAO and Hipparcos Star Catalogs	31,090
Messier Catalog (M)	110
Caldwell Catalog	109
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645

SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5 Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 9-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 125,000-object onboard celestial software library; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords are available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

INTRODUCTORY PRICES
MEADE LX200GPS
SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	125,000 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website**
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01. ** As of 11/5/01.

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COVER PHOTO: Robert Gendler

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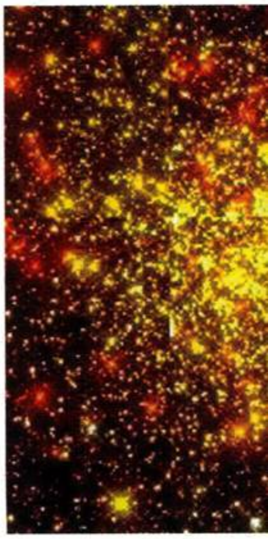

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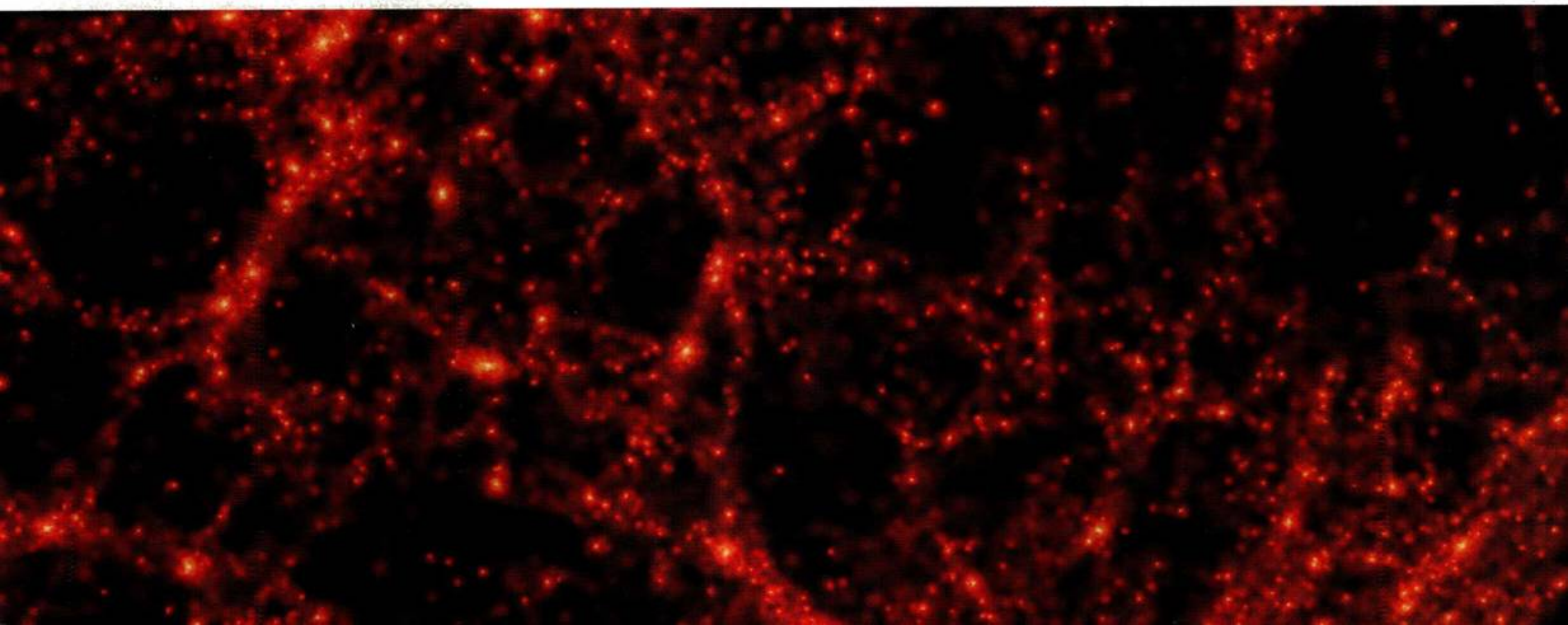

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Clear Skies

Thirty years ago I met a man at the bus station in Herat, Afghanistan. He wore a tribal hat from the region, the kind that looks something like a tea cozy, and his beard was trimmed in an Afghan style. Afghans often spoke to him in Pashtun or Tajik, though most of the people I met there spoke English. Instead of the embroidered sheepskin coats that Western travelers often bought in the country, this man wore an English tweed jacket purchased at the C.A.R.E. bazaar in Kabul. Soon after I entered the station, he offered me cookies in perfect English. He was, afterall, from Long Island but he had the Mediterranean coloring that made it easy to pass himself off as a native anywhere from Spain to India. I didn't take his cookies. Later, however, I did marry him.

He was one of those men I've mentioned in this column before, who tried to show me Orion for the first time, but he didn't stop there. He knew most constellations visible from December's dry, western Afghanistan. The night skies were perfect — similar to ones in Sonora, where the sky is sometimes so glorious you have to stop and get out of your car to study it.

I recently read an essay in the *New York Times* by a woman from Wisconsin who traveled to Afghanistan 30 years ago. She talked about how kind people (both men and women) were to her there, as they were to me. She also mentioned inky black skies that could easily be read from the desert. In 1971, there were few electric lights. Many of the cafes and small hotels were lit by oil-burning lamps. To offer a greeting of "clear skies" would have been ludicrous. There were no other kinds.

Those skies will probably never be the same. After the bombs stop falling, American dollars will flow like water into a parched nation. And so they should. When I was there, Herat had open sewers; old men shaved and kids did family dishes in the clean water that ran in the ditch on the side of the street opposite the sewer. I was 25 then and only the people younger than I was had been vaccinated against smallpox. The traces of the disease were on nearly every adult face. Even in those days, women always covered themselves in burqas. Then there was no Taliban to order them around, only ordinary husbands.

Before it was halted by Russian bombs, progress managed to seep acrosss the borders. It brought smallpox vaccine to what seemed the last place on Earth. It also brought new rounds of invaders to a country rudely familiar with invasion. Now it threatens to haul a very old-fashioned population, a population of nomads, into our 21st century. When this war ends, those 25 million people will be healthier and wealthier than they have been for 200 years. But then the true cultural change begins.

In 20 years, Herat will probably have shopping malls; lights will run among suburban houses. Those perfect skies (and much else) may be gone. Or perhaps Afghanistan will rebuild itself with low-pressure sodium streetlights and a road system based on the new and marvelous Segway personal transport machine.

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An ETX is astronomy made simple!

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3. **Watch as the telescope moves to the object and places it in the field of view — *automatically!***

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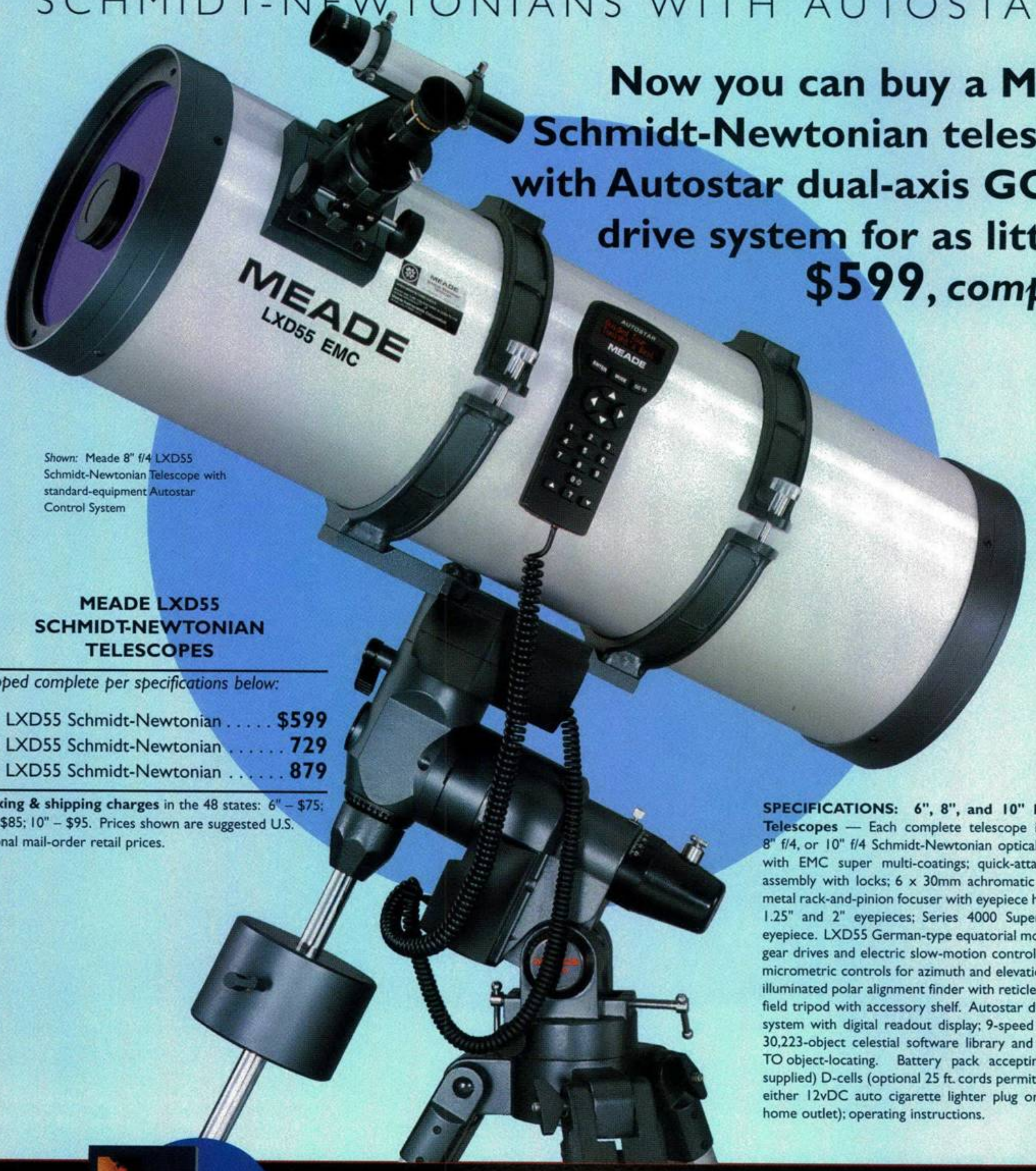
MEADE® LXD55 6" 8" 10"

SCHMIDT-NEWTONIANS WITH AUTOSTAR®



Now you can buy a Meade Schmidt-Newtonian telescope with Autostar dual-axis GO TO drive system for as little as $599, *complete!*

Shown: Meade 8" f/4 LXD55 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System

MEADE LXD55 SCHMIDT-NEWTONIAN TELESCOPES

Shipped complete per specifications below:

6" LXD55 Schmidt-Newtonian	**$599**
8" LXD55 Schmidt-Newtonian	**729**
10" LXD55 Schmidt-Newtonian	**879**

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.

SPECIFICATIONS: 6", 8", and 10" LXD55-Series Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; all-metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

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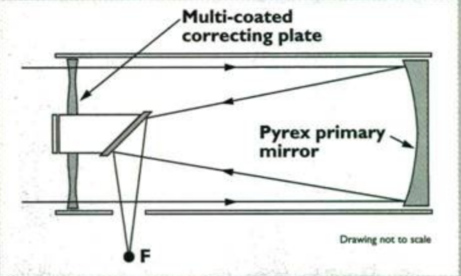
Every Meade LXD55-Series Schmidt-Newtonian telescope includes this listing of standard equipment:

Schmidt-Newtonian optical systems: Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Combined with fast f/4 (8", 10") or f/5 (6") optics, the standard-equipment Super Plössl 26mm eyepiece yields an actual field in excess of 1.3°, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution. The optics are mounted in machined aluminum cells fitted to white-enameled metal tubes; each tube accepts the giant Meade rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces.



The Meade Schmidt-Newtonian Optical System.

LXD55 Equatorial Mount: Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

All LXD55 telescopes include an illuminated polar alignment finder as standard equipment.

Autostar Dual-Axis Electronic Control System: A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class:

Automatic GO TO capability at 4.5°/second on both axes simultaneously, to 30,223 database objects, including:

13,235 deep-sky objects — galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs.

16,888 stars sorted by name, SAO catalog numbers, double and variable stars.

50 objects in the Solar System; 8 major planets from Mercury to Pluto; the Moon; 26 asteroids; 15 comets.

50 Earth satellites; 200 memory locations for user-defined objects.

Automatic GO TO capability to *any* object of known R.A. and Declination.

Nine selectable slew and slow-motion speeds: 4.5°, 3°, and 1.5°/sec, 128x, 64x, 16x, 8x, 2x, and 1x sidereal.

Automatic sidereal-rate tracking in R.A. keeps objects precisely centered in the field.

Control of the telescope through your PC and full upgradability over the Internet, using the RS-232 serial interface. (Requires optional #505 Connector Set.)

Battery Pack (12vDC): Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

Astrophotography and CCD imaging: Armed with their fast photographic speeds, Meade LXD55 Schmidt-Newtonians are ideally suited for deep-space astrophotography and CCD imaging at the telescope's prime focus.

HBX
12vDC
ON - OFF
AUX
DEC

The LXD55 control panel is located below the upper bearing of the polar axis.

***Below, left to right:* Meade 6" f/5, 8" f/4, and 10" f/4 LXD55 Schmidt-Newtonian telescopes.** Each telescope is shipped complete with all equipment shown.

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Meade LXD55 Schmidt-Newtonians open up the skies to images and capabilities previously unavailable in telescopes of their aperture and price level. Consider what a Meade LXD55 telescope can do for your observing program:

6" LXD55 – Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope moves effortlessly and automatically from major planet to asteroid to galaxy to nebula at 4.5°/second, placing every object in the center of the telescopic field. Study fine fault lines on the Moon, structural detail in Jupiter's cloud belts and Red Spot, the Cassini division in Saturn's rings, and much more.

8" LXD55 – With 78% more light-gathering power than the 6" model, the 8" LXD55 roughly triples the number of observable objects in deep-space and resolves extremely fine planetary detail as well: Jupiter's cloud belts are seen as a web of intricate discontinuities; transits and shadow transits of Jupiter's main satellites are observable; six of Saturn's satellites may be seen in revolution about the planet. Deep-space phenomena take on new character with the larger 8" aperture, as Autostar moves the telescope automatically from one spectacular object to the next. CCD images at the telescope's prime f/4 focus show a new level of resolution and detail after only a few minutes' exposure.

10" LXD55 – A quantum leap in image brightness and resolution, the 10" LXD55 provides for a lifetime of serious study in deep-space or within the Solar System. Use Autostar to take an automatic tour, on any given evening, of, say, the 200 brightest diffuse nebulae, spiral galaxies, and globular star clusters. Or, with Autostar's pushbutton electronic slow-motion controls, scan the surface of the Moon at high magnification. Let Autostar locate and center in the field the outer planets Uranus and Neptune, now visible as finite-sized orbs, or Pluto, at the telescope's very limit of observability. It is an uncommon observer who might outgrow the capabilities of the Meade 10" LXD55.

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32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

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#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

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Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. *Includes multi-coated precision optical flat made at the Meade factory;* with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

#911B
#911N
#910B
#910N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

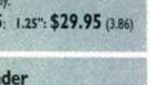
Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces.

$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-10; or for visual applications with 1.25" or 2" eyepieces.

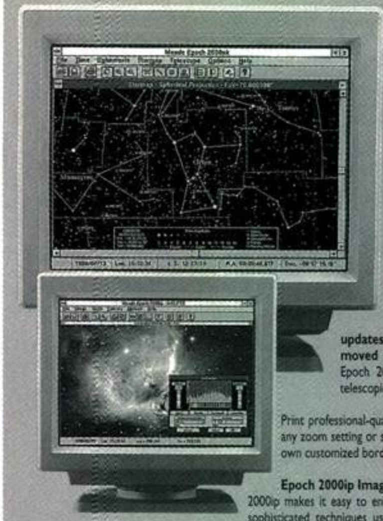
249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)

15.00 (3.86)

#644

#647



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs; Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP	**$99**
LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk	**25**
EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP	**99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror (above). Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

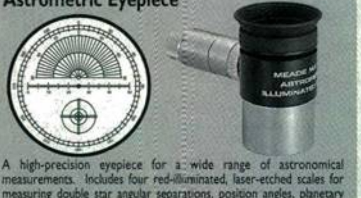
$34.95 (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photoguiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:

99.95 (8.58)

#776 Case for ETX-105EC:

99.95 (8.58)

#775 for ETX-125EC:

149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70	**19.95**
#673 for ETX-90	**24.95**
#675 for ETX-105	**27.95**
#678 for ETX-125	**29.95**

Advanced Field Tripod for ETX-125

#887: Yields rock-solid stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

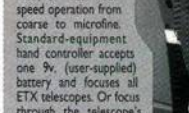
#889 Adapter:

$69.95 (7.70)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)



ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:

$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:

$119.95 (6.85)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
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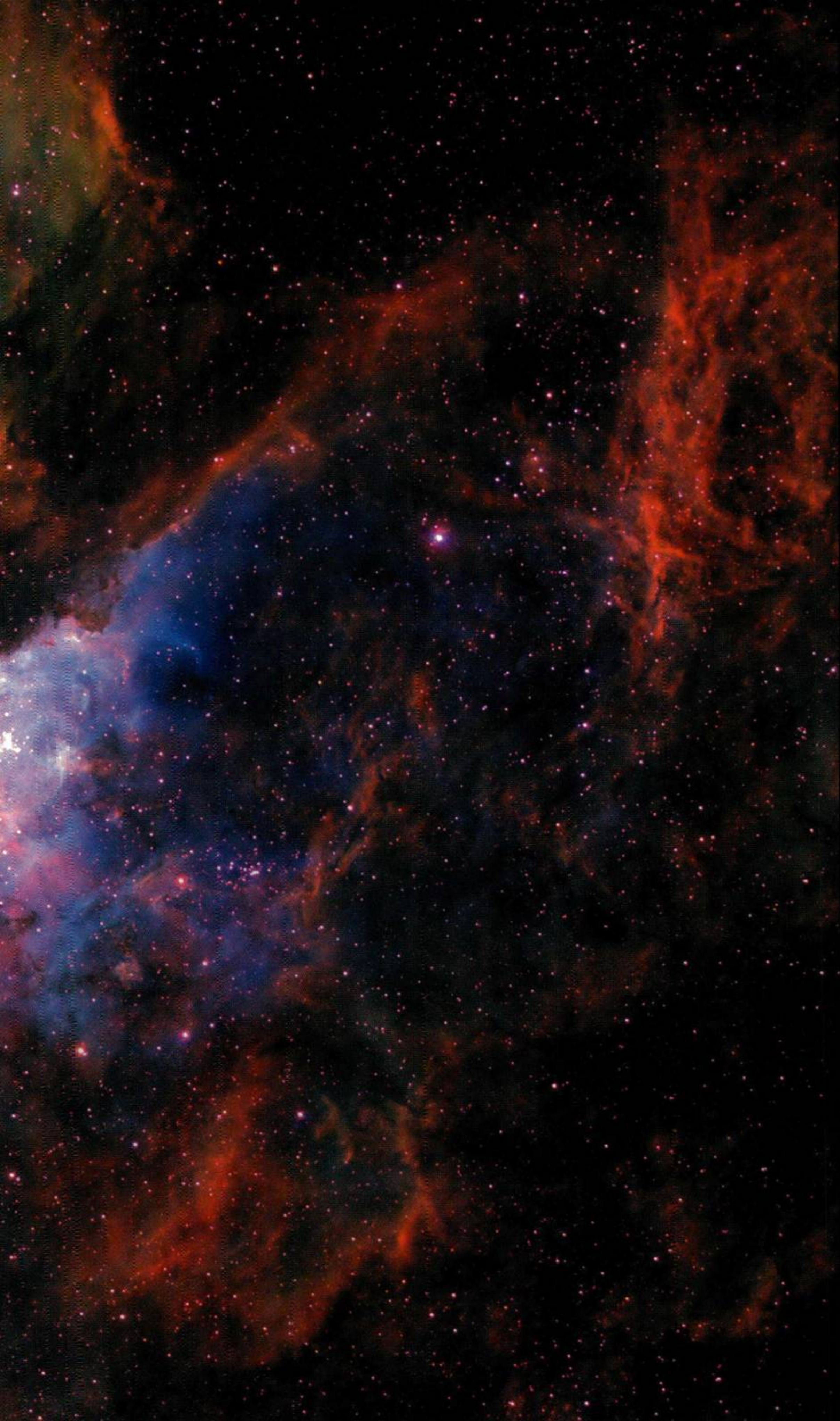

sky Gem

Carina's Southern Charm

Like an alluring southern belle, the Eta Carinae Nebula (NGC 3372) entices astronomers with equal parts mystery and beauty. The brilliant blues (oxygen) and fiery reds (hydrogen) of this giant star-forming region were captured with the Curtis-Schmidt telescope, 50 miles east of La Serena, Chile.

N. Smith/U. of Minnesota/NOAO/NSF

Neighborly Astronomy

Reading Paul Atkinson's story in Hot Shots (December 2001) reminded me of a similar neighborly experience I encountered last summer.

In July 2001, I was returning home from shopping, carrying the latest copy of *Astronomy*, when my next-door neighbor stopped me outside her apartment and asked me what I had bought. I showed her the cover of the magazine, featuring Mars, and she began asking questions. I explained that the Red Planet would be dominating the night sky over the next month and that atronomy enthusiasts, including myself, had been eagerly awaiting this event. I also explained to her how to find Mars in the sky. She appeared quite interested.

That evening, after about three hours of observing, I was about to retire for the night when I heard my doorbell ring. I opened the door to find my neighbor, her husband, and their five children, all bearing cartons of Indian food. They politely asked if they could come into my home and view the Red Planet through my telescope. How could I refuse? The food was delicious, and the evening turned out to be one of the most enjoyable neighborly get-togethers I have ever experienced. — *David E. Wiggins, London, England*

Mysterious Mars beckoned beginner and veteran observers alike in July 2001. Don Parker

A heartfelt thank you

I would like to thank all of the amateur astronomers who contributed to the collection at Astronomy Field at the Black Forest Star Party. It was uplifting to see the way the astronomical community came together for this cause. The total amount collected was $565, and a money order in this amount was sent to the Salvation Army Twin Towers Fund. Thanks again for the generosity of all who contributed. — *Vaughn Nickerson, Upland, Pennsylvania*

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EXTRASOLAR PLANETS

Astronomers Probe Alien Skies

▶ On June 6, 1761, while observing a rare transit of Venus across the disk of the sun, Russian astronomer Mikhail Lomonosov detected the first planetary atmosphere beyond Earth. Now, 241 years later, a team of astronomers has used the Hubble Space Telescope to probe the atmosphere of a distant world 150 light-years outside of our solar system as the planet traversed the face of its host star.

Canadian astronomer Dave Charbonneau of Caltech led the team, which discovered sodium in the atmosphere of a planet orbiting the solar-type star HD 209458. While the discovery comes as no surprise — Charbonneau and his colleagues expected to find sodium — it points to an exciting future when astronomers will be able to study the chemical (and perhaps life-sustaining) characteristics of extrasolar planets.

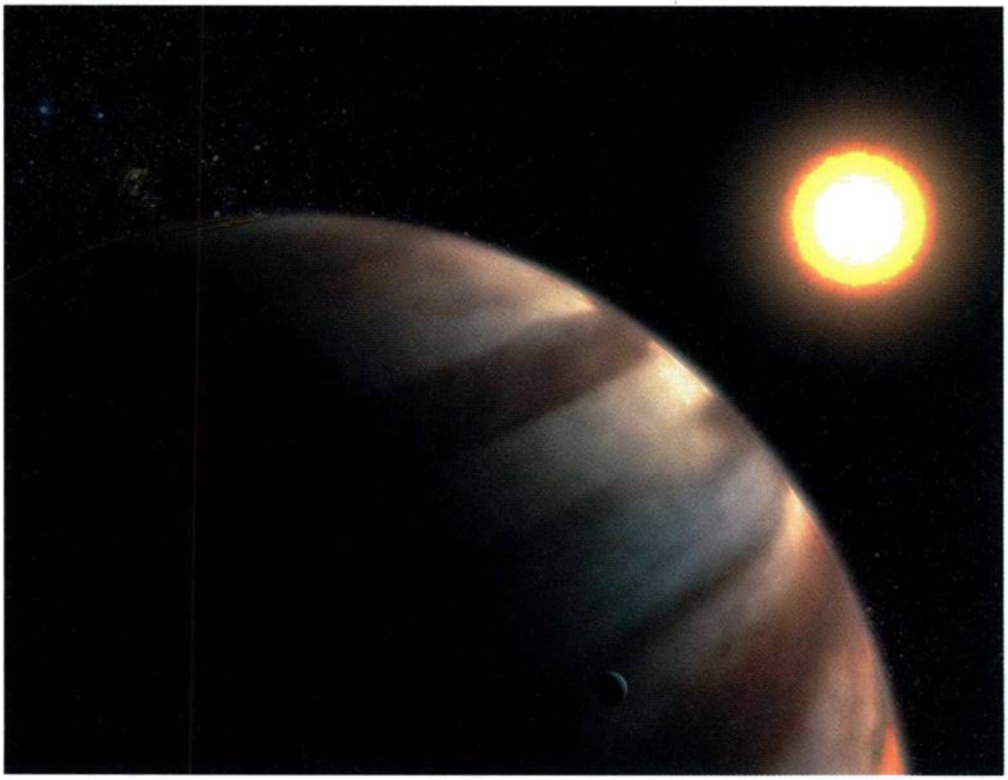
The planet belongs to a bizarre class known as hot Jupiters. It contains 70 percent the mass of Jupiter, yet races around its host star every 3.5 days at a mere 4.2 million miles — less than 1/20 the Earth-sun distance. At that distance, the star bakes the upper cloud decks to a blistering 2000° F.

In 1999, Charbonneau's team codiscovered the gas giant planet, which regularly transits its star. With the hope of being able to detect atmospheric gases like sodium, the team observed three separate transit events in April and May 2000 with Hubble's imaging spectrograph. It found that the amount of starlight absorbed by sodium atoms varied as the planet ventured in and out of transit. Moreover, the team has since determined that sodium in the atmosphere of HD 209458's planet was indeed stealing some of the star's light as it crossed the star's disk.

"Their discovery of the sodium spectral line in the atmosphere of the planet orbiting HD 209458 is absolutely secure. I have no doubt that this result is correct," says University of California, Berkeley astronomer Geoff Marcy, who leads the team that has discovered the majority of the 80 or so planets that have been found outside the solar system.

Charbonneau expected to find sodium because it's easy to detect and because it is common in the atmospheres of low-mass stars and brown dwarfs. But surprisingly, his team found less sodium than expected. He suspects that either high cloud decks are blocking the star's light before it can reach lower, sodium-rich layers, or the sodium has combined with other molecules to form sulfides. "Observations in the next year will allow us to determine which is the dominant effect," says Charbonneau.

Charbonneau's team, which includes Tim Brown of the National Center for Atmospheric Research, Robert Noyes of the Harvard-Smithsonian Center for Astrophysics, and Ron Gilliland of the Space Telescope Science Institute, has applied for more Hubble time to look for water vapor in the planet's atmosphere. In addition, ground-based transit observations could detect methane and carbon dioxide. "Now that we have this tool, we can look in other portions of the spectrum for a whole host of other atoms and molecules we expect to be there," says Charbonneau. — Robert Naeye, Astronomical Society of the Pacific


STScI/AVL/G. Bacon

Hubble helped astronomers detect signs of a planetary atmosphere 150 light-years away, depicted here in an artist's rendering.

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RADIO ASTRONOMY

Radio Requiem for a Dying Star

▶ A team of astronomers using the National Science Foundation's Very Large Array (VLA) radio telescope has stumbled upon a never-before-seen phenomenon — an old star in the midst of its brief transformation into a planetary nebula.

When a low-mass star reaches the end of its life, it ejects its outer layers of gas before collapsing under the weight of its own gravity to become a white dwarf. Consequently, the star heats up and pours out ultraviolet light, which tears apart the gas molecules. In turn, the gas then glows, in various shell-like shapes, producing a planetary nebula.

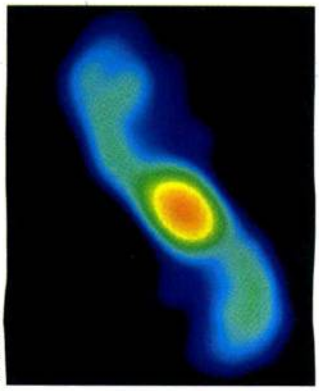
"This is the first time that anyone has seen a star that is so clearly going through this transformation stage," says Yolanda Gomez, an astronomer at the Institute for Astronomy at the National Autonomous University in Mexico City, Mexico. The team reported its findings in the November 15 issue of *Nature.*

The researchers made the unique discovery while observing a planetary nebula called K3–35 — 16,000 light-years from Earth in the constellation Vulpecula. While the structure of the object is similar to other planetary nebulae, with a "doughnut" of gas surrounding the central star and lobes of material flowing outward, the team was surprised to find an unusual difference. "We are seeing radio waves emitted by water molecules in this planetary nebula," says Gomez.

"We believe the water molecules are all destroyed within only 100 years of the beginning of this stage, so we are seeing this star during an extremely brief transition period of its life," adds Gomez. The team has concluded that K3–35 began its transformation into a full-fledged planetary nebula only since 1984.

"This is extremely exciting, because we now have a laboratory for watching this process take place over the next few years," explains Luis Miranda of the Institute of Andalucia in Spain. — Elesa Janke

K3–35 began shedding its skin while Ronald Reagan was securing his second presidential term.



VLA/NRAO

DIGITIZED SKY SURVEY II

NASA/Caltech/DSS-II

A DIGITAL DANCE OF BLUES AND REDS helps to point the way for NASA's Hubble Space Telescope. This photo, originally taken with the Oschin Schmidt Telescope at Palomar Observatory, is one of thousands that have been scanned by scientists at the Space Telescope Science Institute to create the second Digitized Sky Survey (DSS-II), which aids Hubble in locating celestial targets. What's more, the DSS-II is valuable in its own right, as complete coverage at both blue and red wavelengths provides information over a wide spectral range for nearly one billion deep-sky objects. Here, the Rosette Nebula (NGC 2237–9) in the constellation Monoceros displays its striking beauty. The emission nebula lies 5,500 light-years away and spans more than 100 light-years.

PLANETARY SCIENCE

What Bubbles Beneath?

▶ In terms of geology, Earth and Mars may have much more in common than superficial features like gullies and polar ice caps. Scientists have recently proposed a theory that draws the two distant worlds together in terms of how more robust landscape features such as mountains and plateaus emerge.

This budding theory is known as the "superplume" concept, formulated in the mid-1990s by the Japanese geologist Shigenori Maruyama at the Tokyo Institute of Technology. Superplumes involve the transfer of heat from a planet's super-hot inner core via the movement of magma toward a surface landmass, ultimately causing the landmass to bulge outward.

According to Maruyama, his theory coupled with plate tectonics — a concept that explains how lighter continental plates and heavier oceanic plates float atop hot magma and collide to form terrestrial mountains and earthquakes — unites seemingly alien geological processes between the two planets. For example, Maruyama points to the emerging supercontinent beneath the Himalayas and the ongoing creation of a huge, dome-like martian structure known as the Tharsis Bulge.

The process may also explain similarities between the continent of Africa and the Tharsis region, says Maruyama. — Paul Morledge

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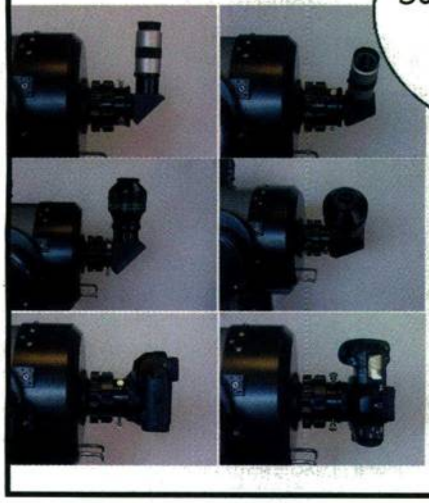

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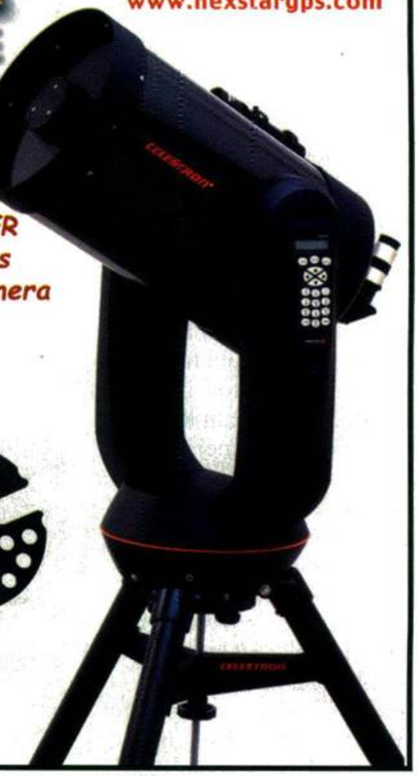

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Could the secrets of Mars's past be revealed beneath the Himalayas?

SPACE ROCKS

Tearing Apart Asteroid Families

▶ Asteroid groups, or families, tend to stick together — that is, until the sun's subtle, yet unrelenting, energy produces a variation in the traditional orbit of an individual asteroid. According to new research, tens of millions of years of solar radiation can gently nudge a renegade asteroid from its comfort zone into a more chaotic orbital path known as a resonance. There, the asteroid is also subject to slight gravitational kicks from nearby planets. What's more, these forces can conspire to send an object on a collision course with Earth or other celestial bodies.

Blame it on the Yarkovsky effect, says a team of astronomers from the Southwest Research Institute in Boulder, Colorado.

Named for I. O. Yarkovsky, the Russian engineer who discovered it in the early 1900s, the Yarkovsky effect accounts for the slow but steady drift of an asteroid from a predictable path to a new, Earth-crossing orbit. In the November 23 issue of *Science*, William Bottke, lead researcher of an American-Czech-French team, explains how the Yarkovsky effect is likely the dominant force behind past and future Earth-asteroid encounters.

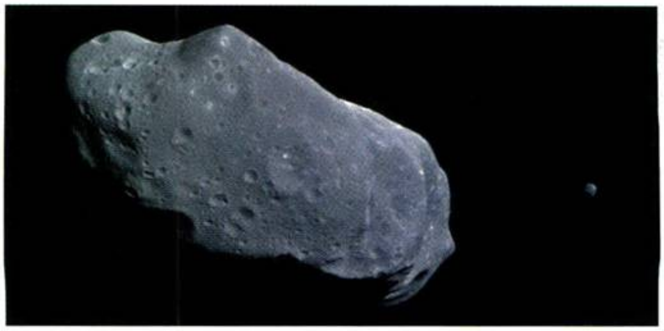
Many asteroid families, produced by catastrophic collisions among asteroids larger than about 60 miles (100 kilometers) in diameter, have long been known to reside in a generally stable neighborhood — or asteroid belt — somewhere between Mars and Jupiter. Prominent surnames include Koronis, Eos, and Themis. Most of these asteroid groups are scattered in asymmetrical distributions, with close-knit and distant family members.

Bottke's team concentrated on computer modeling of the Koronis family and discovered a number of influential factors affecting the errant orbital behavior of wandering asteroids: spin axis orientation and spin period, as well as thermal and material properties.

From the 210 test asteroids the team tracked, it found the most significant factor influencing the magnitude of the Yarkovsky effect was asteroid size. For an asteroid to be strongly influenced by the Yarkovsky effect, the space rock must be susceptible to hemispheric temperature asymmetries (day/night variations). In addition, asteroids must be larger than a few centimeters across.

In conjunction with the spin axis orientation of the asteroid, the amount of light that each hemisphere receives determines whether more thermal energy is lost on the night side (causing the asteroid's orbit to decay) or the day side (giving the asteroid an orbital boost). However, the bigger the object, the less this temperature gradient will affect its orbit as it absorbs and radiates thermal energy.

Overall, the Yarkovsky effect is most important for meter-sized objects, causing an orbital change of perhaps 0.001 AU per million years — which also helps explain the rarity of near-Earth asteroid collisions involving asteroids larger than 20 kilometers.
— CAROL RYBACK



New research indicates that constant exposure to the sun may nudge asteroids too close for earthling comfort. NASA/JPL

SOHO MISSION

Solar Gas Seen Going the Wrong Way

▶ The joint NASA/ESA Solar and Heliospheric Observatory (SOHO) has spotted some peculiar clumps of gas fighting against the outward flow of the solar wind and diving back toward the sun.

At first, puzzled scientists thought they were misinterpreting the SOHO images, but after witnessing about 8,000 such inflows over the past five years, some believe that collapsing magnetic field lines drag these gas clouds inward toward the sun's surface.

Neil Sheely and Yi-Ming Wang of the Naval Research Laboratory uncovered the infalling gas clouds in images from SOHO's LASCO *instrument,* which blocks light from the bright solar surface.

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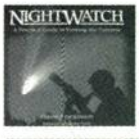

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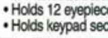

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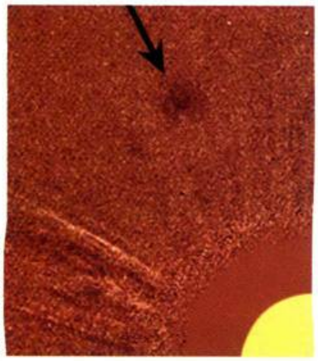
As their *Astrophysical Journal Letters* paper reports, the blobs can start their inward descent as high as 1.7 million miles (2.7 million kilometers) — twice the sun's diameter — above the visible solar surface and typically come to rest about 435,000 miles (700,000 km) from the surface.

The scientists also note that these plunging gas clouds are most common during heightened solar activity. Moreover, groups (as many as 20 per day) tend to concentrate in particular regions that rotate along with the sun.

From these observations, Sheely and Wang believe that the clumps of gas get caught between opposing magnetic field lines, which can short-circuit and collapse, subsequently dragging the clouds toward the sun.

"Before this discovery by SOHO, no one had any idea that gas could travel the wrong way and be pushed back toward the sun," says SOHO project scientist Bernhard Fleck. "Now we must learn from the inflows how the sun regulates the magnetic fields carried by the solar wind, which are a key driver for the space weather we experience." — Vanessa Thomas

A misdirected blob of solar gas (arrowed) heads back toward the surface of the sun, lower right.



NASA/ESA/SOHO

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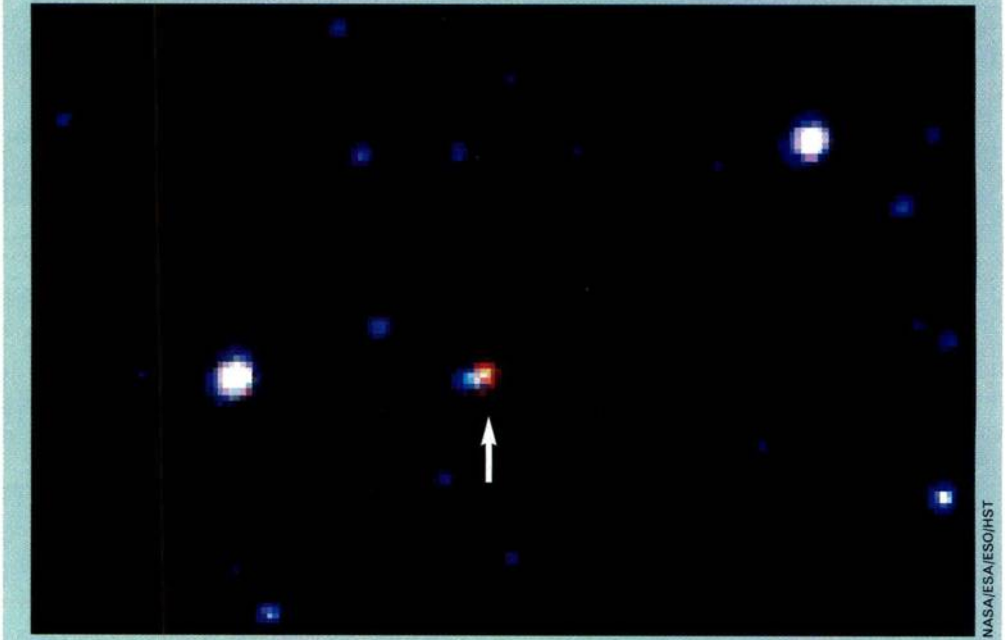

NASA/ESA/ESO/HST

OUT OF THE DARKNESS a dim object makes its presence known. Though it may appear insignificant, this NASA/ESA Hubble Space Telescope image marks an important milestone in the search for the universe's missing matter. For the first time, astronomers have captured a chunk of this elusive dark matter on camera. Just 600 light-years away in the halo of the Milky Way Galaxy, this dwarf star (arrowed) was indirectly discovered six years prior, through its gravitational effect on the light from a background star (adjacent blue object) 170,000 light-years away in the Large Magellanic Cloud. Using photographic and spectral analysis, astronomers have determined that the dwarf star has a mass just five to ten percent that of the sun. The discovery bolsters the belief that a significant fraction of the normal dark matter in the universe (faint stars, neutron stars, black holes, and planetary-mass objects) could reside in the outskirts of normal galaxies like the Milky Way.

PLANETARY SCIENCE

Red Rovers Get Ready for Mars

Sending bulldozer rovers into space may sound like kids' play, but it's serious business for NASA engineers who hope to eventually send pint-sized robotic vehicles to investigate the Red Planet.

Now under development at the Jet Propulsion Laboratory (JPL) in Pasadena, California, these prototypes resemble a cross between a bulldozer and a dump truck. They will have the same capabilities (relative to their size) as their larger brethren — and then some. Bulldozer rovers, weighing in at about eight pounds (3.6 kg), will work without an operator, and are intelligent enough to right themselves or help each other get out of awkward positions.

Brian Wilcox, Supervisor of the Robotic Vehicles Group at JPL, expects the dozer rovers to serve as the future workhorses of Mars missions. A number of tiny vehicles can work more efficiently than one large bulldozer rover, and will be much easier to transport, he says.

"We think a greater amount of terrain can be excavated if the workload is shared among several smaller vehicles," says Wilcox. "Smaller solar-powered vehicles have a higher power-to-weight ratio than bigger vehicles, yet together can perform the same tasks as a large one."

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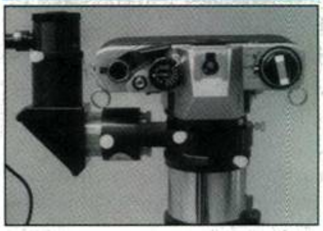

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NASA/JPL

Robot rovers like these dozers may one day literally pave the way for manned exploration of the Red Planet.

Wilcox plans on sending a fleet of about 100 of these rovers to Mars late in this decade or early in the next. During these interplanetary missions, the dozer rovers will be programmed to help sustain a human presence by digging utility trenches, helping to create buried habitats, or looking for life in all the right places.

A central control tower will not only provide a 360° view of the terrain, but also direct the rovers' movements. When working out of sight in a hole or a ditch, the control tower can unfurl a reflector that diverts solar energy down to the rover.

Satellite probes and mapping Mars's surface would identify potential sites for excavation. One of the best places to deploy the rover fleet would be in areas such as an extinct hot spring, layers of ice, or in groundwater reservoirs if they are discovered, says Wilcox. "The dozer rovers could conduct scientific investigations and excavate the site piece-by-piece, just as humans would on an archeological dig," he says.

Presently equipped with scoop shovels and arms that can dump the load into an overhead bucket, future prototypes will also have some sort of pickax to break up larger rocks or cut through harder terrain, says Wilcox.

Engineers also plan to program the dozers to return their cargo to a central station for scientific analysis. Advanced dozer models may even play a hand in mining resources useful to humans living in a future Mars outpost.

Dozer rovers operate using processor and software technology originally designed for a Japanese nano-rover asteroid mission. With four working prototypes currently, Wilcox says that one of his team's primary goals is to determine the optimum size of the rovers. They expect to spend at least the next five years developing and testing the various prototypes.

JPL is the leading American center for robotic exploration of the solar system. "When people hear about the work we do, they sometimes think we're just talking science fiction," says Wayne Schober, JPL's manager for advanced robotics surface systems.

"We're not all fun and games. We mean business," he says.

JPL researchers are also working on the "next generation" vehicles — such as wind-propelled tumbleweed balls, blimps, and all-terrain vehicles — for air, surface, and subsurface planetary exploration. Eventually, they hope to send robotic armadas to Mars and Venus, as well as the moons Europa and Titan. — C. R. ■

For the latest astronomy news as it breaks, visit us at www.astronomy.com

Playboy Hosts a Star Party

On November 15, world renowned science fiction author Sir Arthur C. Clarke and the Space Frontier Foundation jointly hosted the first annual Clarke Gala at the Playboy Mansion in Los Angeles, California. The soiree, which was emceed by CNN's Larry King and featured a reading from Clarke's "Rendezvous with Rama" by Academy Award-winning actor Morgan Freeman, was held in honor and celebration of the longstanding creative union between storytellers and space explorers. Clarke, who is credited with inventing geosynchronous satellite communication systems, addressed the guests by live satellite feed from his adopted home of Sri Lanka. In addition to the picturesque scenery of the Playboy estate, guests were treated to a first-class space exhibit that included telescope stations for viewing the heavens.

NASA Takes Up Solar Wind Collection

One million miles upwind from Earth, NASA's Genesis spacecraft unfurled its special collector arrays and began scooping up atomic bits and pieces from the solar nebula on December 3. The Genesis mission, managed by the Jet Propulsion Laboratory in Pasadena, California, is the most recent such sample return mission since the Apollo 17 moon trip in 1972. Moreover, the return of Genesis and its payload to Earth in September 2004 will mark the first return of an extraterrestrial sample from beyond the moon. Mission managers plan to keep the payload from becoming contaminated on its return to Earth by catching the capsule in mid-air with a specially-equipped helicopter.

JPL/LMA

With room to spare, Genesis is ready to bring back the sun.

Looking to Space to Save the Seals

In recent years wildlife biologists have been turning to space in a desperate attempt to save the northern fur seal and Stellar sea lions. With fewer than 40,000 remaining, Stellar sea lions are an endangered species. And northern fur seal numbers have dwindled to below one million in American waters. The Alaska Ecosystems Program, which monitors both species and their habits in the Gulf of Alaska and the Bering Sea, employs both the National Oceanic and Atmospheric Administration's polar-orbiting satellite and NASA's Topex/Poseidon satellite. With help from these orbiting observing stations, scientists can record the marine mammals' paths as they forage for food and migrate, as well as monitor climatic changes in their habitat.

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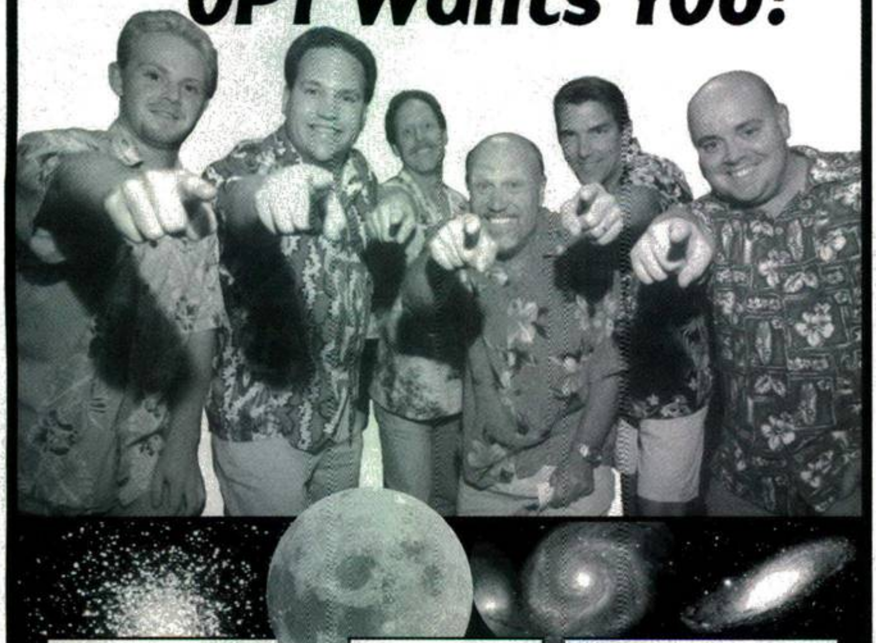

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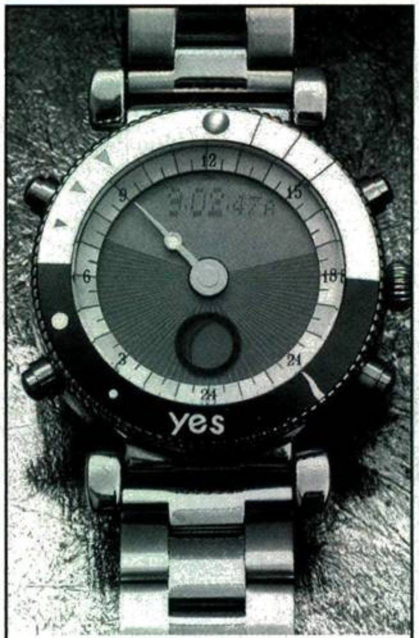

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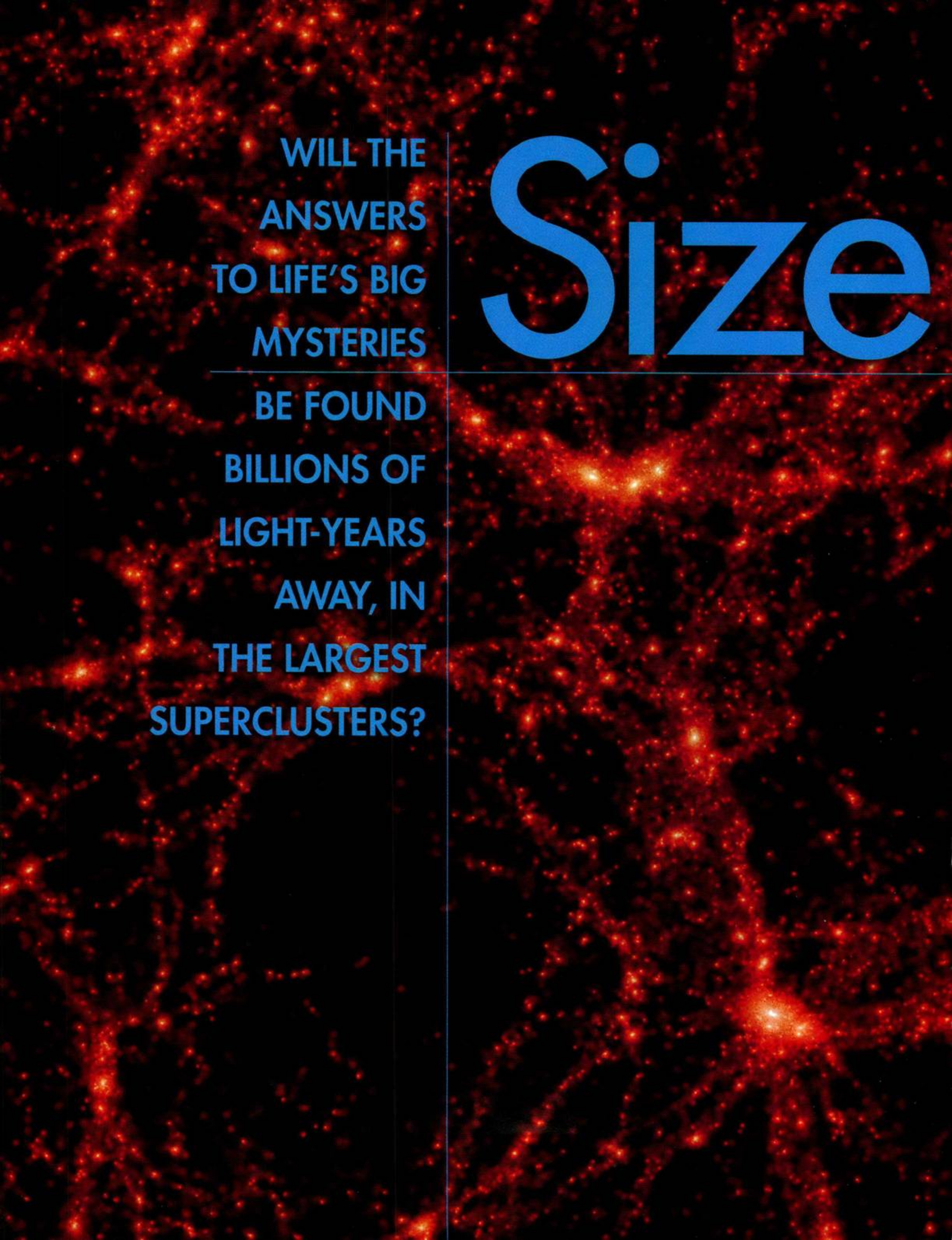


Size

WILL THE ANSWERS TO LIFE'S BIG MYSTERIES BE FOUND BILLIONS OF LIGHT-YEARS AWAY, IN THE LARGEST SUPERCLUSTERS?

Matters

BY STEVE NADIS

Previous: Countless galaxies traverse voids like dew on a spider's web. Virgo Consortium/J. Colberg

As strange as it may seem, humans have always been driven to find the biggest items in any category — be it mountains, animals, or personal fortunes. Yet when it comes to identifying the largest structures in the universe, too many questions remain unanswered.

Astronomers know that stars assemble by the billions to form galaxies. In turn, galaxies clump together by the thousands to form clusters and superclusters. But what, if anything, lies beyond? Will recent trends continue indefinitely, with astronomers finding ever-bigger entities as they peer deeper and deeper into space? Or is there some size limit, beyond which no larger structures will ever be observed? Better yet, what are the cosmological implications of either scenario, and will we ever be able to tell the difference?

In truth, the quest to figure out how large superclusters really are, as well as if there are larger entities to be found, derives from more than an obsession with size. Probing the limits of large is just one of many necessary hurdles to clear before we can determine how matter is distributed, how the universe formed, and what its fate will be. But, as it is with many astronomical endeavors, it's a classic case of something easier said than done.

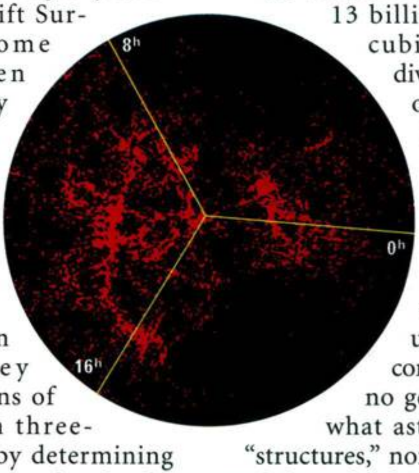
Like fish unaware of the extent of the oceans surrounding them, for centuries astronomers had no real way of discerning just how large the universe and its constituent parts are. In the last few decades, however, larger telescopes and the development of sophisticated detectors ruled by the precepts of quantum physics have allowed researchers to place some hard limits on the structure of the universe. At the same time, they've developed new techniques for mapping out bigger and bigger chunks of space through galaxy redshift surveys that can be used to find three-dimensional associations of galaxies millions of light-years across (see "Redshift Surveys," below). Some astronomers even believe that they may have found the elusive supercluster size cap.

Early indications of a limit on large came from the Las Campanas redshift survey, completed in 1994. The survey charted the positions of 25,000 galaxies in three-dimensional space by determining the celestial coordinates of each galaxy and its redshift as an indicator of distance. As the Las Campanas team uncovered several superclusters, wall-like structures, and vast empty regions of space called voids, they found that large-scale cosmic structures don't become invariably big, but instead seem to have finite dimensions.

Across the globe, astronomers with the Australian-British redshift survey called 2dF — named for the Two-Degree Field spectrograph installed on the 3.9-meter Anglo-Australian Telescope near Coonabarabran, Australia — have set this apparent size cap at about 300 million light-years. By the end of 2001, 2dF investigators obtained redshifts for more than 200,000 galaxies, to create a map of the local universe out to several billion light-years. "Although we're examining just five percent of the sky, that's still big enough to constitute a fair sample," says 2dF team member Karl Glazebrook of Johns Hopkins University. "We're confident, because if you take the volume of space we cover [about 13 billion, billion, billion cubic light-years] and divide it into hundreds of smaller chunks, they all look pretty much the same."

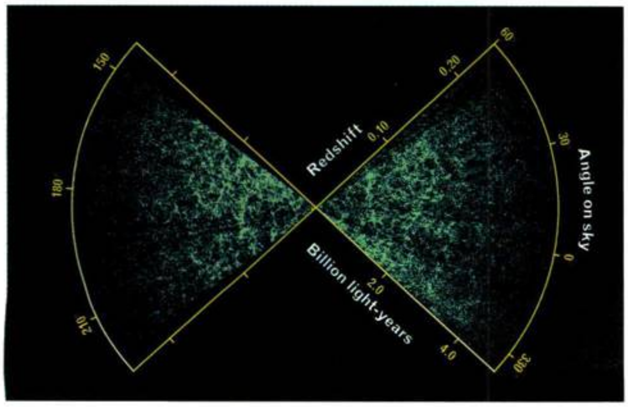
As concepts go, a size cap on superclusters sounds simple enough. Yet it also raises a host of unanswered questions, considering that there is no general agreement on what astronomers mean by "structures," nor are there any hard-and-fast rules for appraising their size. What's more, there are several famous exceptions to the 300-million-light-year cutoff that further confuse these matters of size.

In 1989, for example, two Smithsonian Center for Astrophysics (CFA) astronomers, Margaret Geller and John Huchra, announced the discovery of the "Great Wall" — a vast sheet of galaxies and clusters that extends about 500 million light-years. And just last year, Gerard Williger of NASA's Goddard Space Flight Center in Greenbelt,

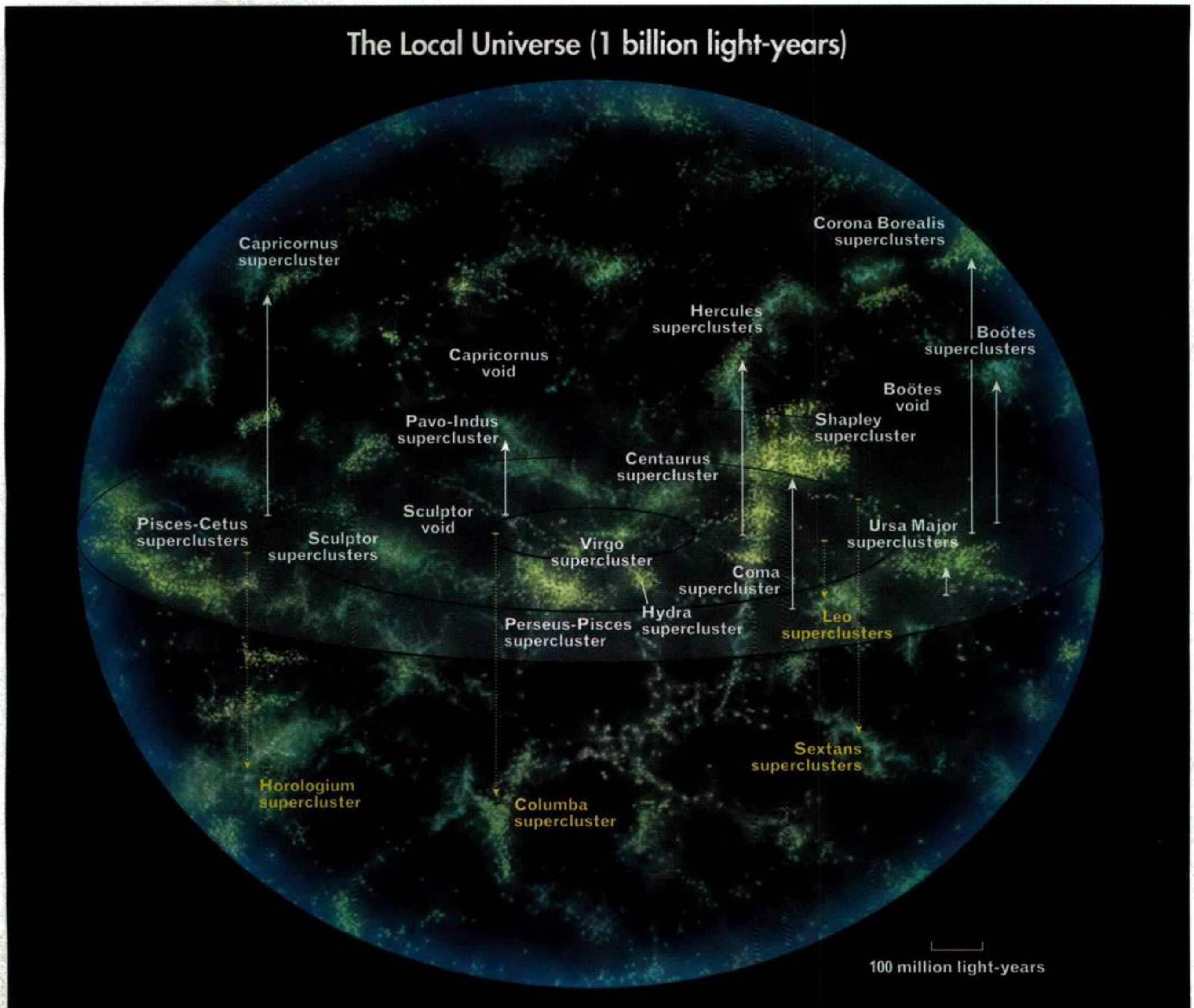


Gigantic galaxy groups like the "Great Wall" (600x250x30 million cubic light-years) continue to puzzle astronomers who study large-scale structure. SAO/M.J. Geller/H.P. Huchra

Redshift Surveys: A little slice of heaven



Galaxy redshift surveys, like this data from the Australian-British 2dF survey, which displays the distances and positions of some 200,000 nearby galaxies, are a crucial tool for astronomers who trace large-scale structure. Light emitted from objects moving steadily away from Earth gets shifted toward longer (red) wavelengths. This effect, called redshift, can be measured for galaxies swept up in the expansion of the universe by a close examination of their spectral features. Galaxy redshifts (quantified by the ratio of the overall change in wavelength to the expected wavelength if the object were at rest) are directly proportional to distance. Therefore, combined observations of galaxy redshifts and sky positions allow astronomers to map nearby superclusters and voids.



The Local Universe (1 billion light-years)

Capricornus supercluster
Corona Borealis superclusters
Hercules superclusters
Boötes superclusters
Capricornus void
Boötes void
Pavo-Indus supercluster
Shapley supercluster
Centaurus supercluster
Sculptor void
Ursa Major superclusters
Pisces-Cetus superclusters
Sculptor superclusters
Virgo supercluster
Coma supercluster
Hydra supercluster
Perseus-Pisces supercluster
Leo superclusters
Sextans superclusters
Horologium supercluster
Columba supercluster
100 million light-years

Heralded by Edwin Hubble's 1923 confirmation that the cosmos is not confined within the Milky Way Galaxy (deep within the Virgo Supercluster at the center of this map), astronomers have since determined that we live in a universe where stars clump, by the billions, to comprise galaxies and galaxy clusters. Galaxy superclusters, the largest of the large superstructures, can stretch hundreds of millions of light-years across the voids of intergalactic space.

Maryland and his colleagues discovered another giant clump of galaxies, measuring about 600 million light-years across in the constellation Leo.

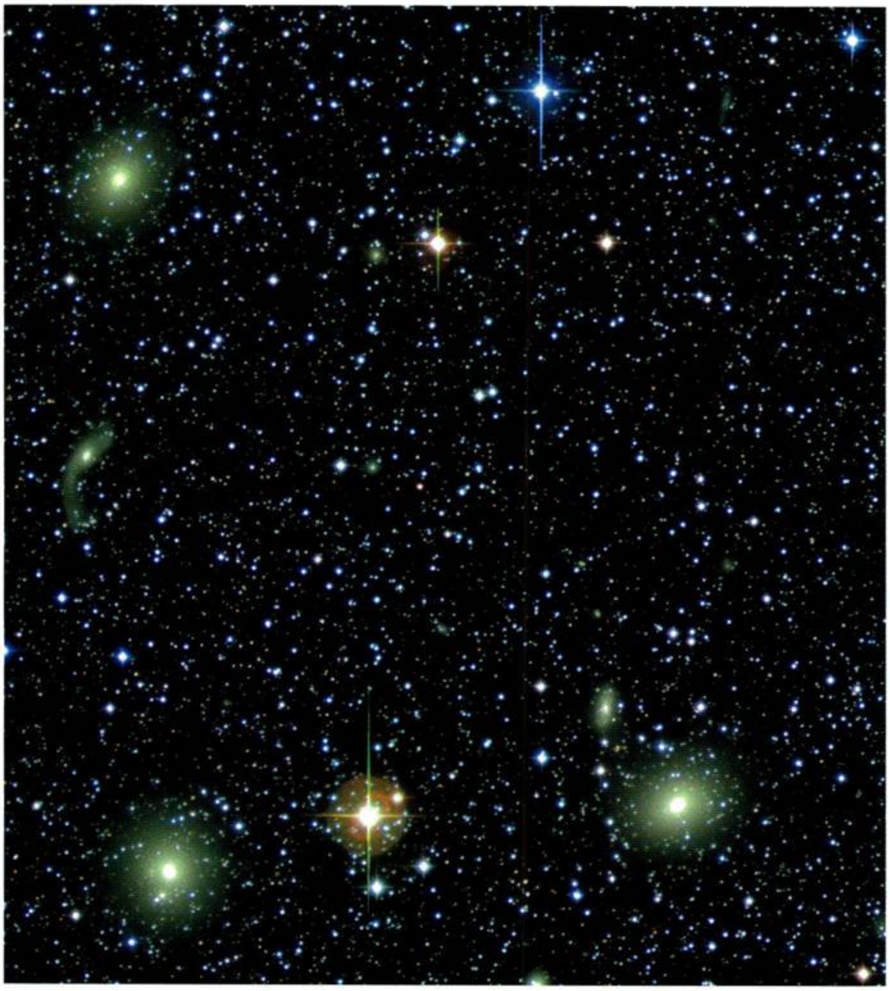
"Even with a size limit set at 300 million light-years," says University of Maine astronomer David Batuski, "from a statistical point of view you'd expect to find a few things that are significantly bigger. But if we keep finding more and more exceptions to this rule, we might wonder whether the limit ought to be extended."

Much of the confusion in the large-scale structure field stems from the language used to describe giant celestial associations. While astronomers largely agree on the terminology for galaxies and galaxy clusters, their language becomes murkier when discussing substantially larger celestial groupings, such as superclusters, which can be arranged like squashed footballs, or sheets and filaments that connect galaxies and clusters. Although some galaxy-rich regions meet the classic definition of a supercluster — a cluster of galaxy clusters — some filaments, walls, and sheets do not.

"There is no agreed upon set of terms mainly because these things are so hard to study," adds University of Hawaii astronomer Patrick Henry. "When you look at a rock, you know what you have. It's much harder to get a grip on these [gargantuan] things."

At the moment, it's not only difficult to define large-scale structures, it's also hard to gauge their size. "To say how big something is, you first have to say what you mean by size, which is a complicated matter," Glazebrook notes. "Do you mean the radius at which matter is falling in toward a gravitational center, or do you use alternative measures?"

To some degree, the problem stems from limitations of technology: Astronomers can spot bright galaxies and clusters more readily than faint objects, which makes it hard to see the full extent of a giant structure. The North Ecliptic Pole Supercluster, which was discovered in 1985, now appears to



Though yet-unseen, the "Great Attractor" lurks behind the Hydra-Centaurus supercluster. ESO

be at least twice as big as originally thought, owing to recent observations from the ROSAT x-ray telescope that revealed 10 galaxy groups hidden among larger clusters. "X rays allow us to see the finer structure in this supercluster and connections that show how the pieces are linked," explains Christopher Mullis, a University of Hawaii graduate student. "It's like being in an airplane and wanting to know how the population is distributed. If you can only see the biggest cities, you have a fairly crude picture. Once you have the ability to detect small towns, you can get a sense of how these cities are connected."

But when astronomers discover clusters and galaxies in the vicinity of a supercluster, how do they know whether these objects are actually part of the grander structure? One simple statistical measure relates to how many galaxies are concentrated in a given volume of space. Areas of high concentration point to what Caltech astronomer Richard Ellis calls "a physically significant structure." Another test uses the distance between galaxies as a way to decide whether a galaxy belongs in a structure or not.

Nevertheless, even when aided by statistical tools, astronomers still have to make arbitrary judgments about size. They have to decide, for example, how much of a density enhancement above average is needed to call something a structure. "If you use twice the average density as the cutoff, then almost everything in the universe is connected in one huge supercluster," says Batuski. He considers a factor of 10 "overdensity" a more reasonable threshold. "At that level, you get a bunch of individual structures that are relatively isolated from each other. But right now, there isn't a clear physical reason for deciding where to cut it off."

Beyond the debate over what constitutes structures, how to measure them, and how big they can get, astronomers are trying to figure out what can be learned from studying huge galactic confederations. "We don't make these maps just because they're pretty," explains Huchra. Rather, the goal is to answer fundamental questions in astronomy, cosmology, and physics.

"Superclusters are so big that their basic pattern couldn't have changed much since the early universe," adds Henry. "So we're seeing what is close to the original pattern of structure, with changes accentuated by gravity." By scrutinizing this pattern, researchers can get clues about the density fluctuations created during the "inflationary" period of the universe, just a fraction of a second after the Big Bang.

Galaxy maps might also reveal whether there is a "preferred scale" for structure in the universe. Astronomers can study this question by means of a mathematical tool called a "power spectrum," which is basically a graph of the observed density of matter in a region versus the average density of space, as a function of scale. They look for deviations from a smooth bell curve in the form of small humps or peaks. Based on a preliminary analysis of 2dF data, Ellis says there might be a peak at about 250 million light-years, suggesting that matter is distributed in lumps of roughly that size and spread evenly throughout the universe.

"Soap bubbles in the kitchen sink have a characteristic size," Henry explains. "Whatever made the fluctuations in the early universe might have also made them a characteristic size."

Better data will also enable astrophysicists to make more precise calculations of the power spectrum. Indeed, that's one of the main premises of 2dF and the Sloan Digital Sky Survey: to compile enough statistics to do what Ohio State University astronomer David Weinberg calls "precision cosmology." These giant surveys, Weinberg says, "will transform the study of large-scale structure into a precision science." By comparison, laboratory physicists can measure parameters like the magnetic moment of a muon to the ninth decimal point. "We're not there yet in cosmology, but we can spot something like a two percent difference in matter density. And that two percent difference might be enough to point us towards new particles or new physics." ■

Steve Nadis is a freelance writer based in Cambridge, Massachusetts. His latest article for Astronomy, *"Out of Sight, Out of MOND," appeared in the August 2001 issue.*

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Alaskan aurora photograph by Mike O'Leary A38443ad

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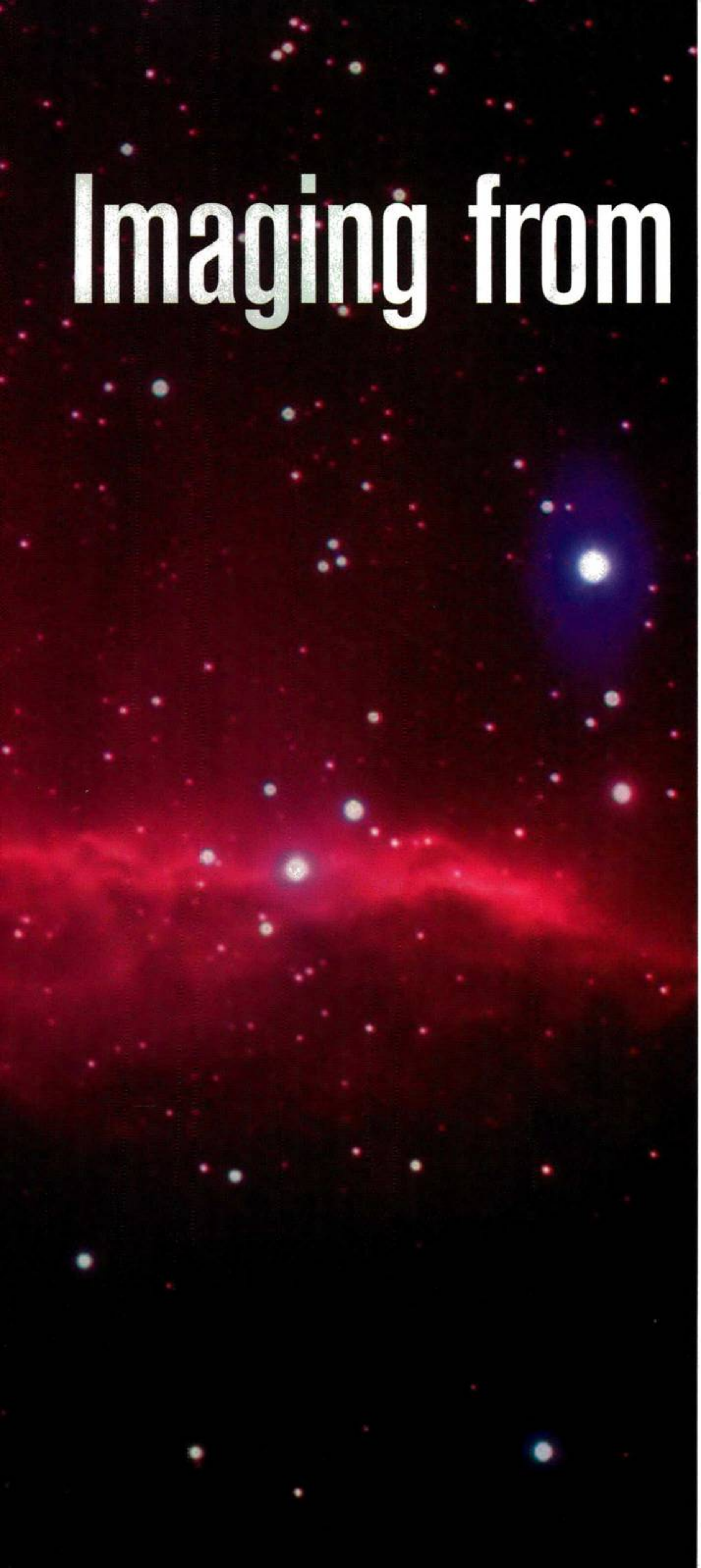
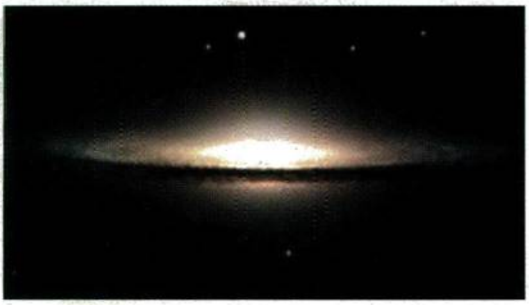
Imaging from the 'Burbs

Photos by Robert Gendler

You can capture gorgeous images right from your own driveway, even if you live in the heart of suburbia, U.S.A. Just ask Robert Gendler. A physician by day, Gendler began his hobby in 1993 at his home outside Hartford, Connecticut, after taking an astronomy course at a local college. Although he says he faces "significant light pollution" where he lives, today he is an accomplished astroimager, with images published regularly in numerous publications. Mainly using his 12.5-inch Ritchey-Chrétien scope and his ST8E CCD camera, he takes all of his photos from his driveway, usually devoting an entire night to a single object. But his favorite part of the process is creating the final image by combining the multitude of individual frames on his computer and watching them come to life. Take a look at our photo gallery to see just how beautiful the universe can be, even from the suburbs. — *Elesa Janke*



This stunning image of the Horsehead Nebula (B33) was captured with a 6-inch refractor at f/5.



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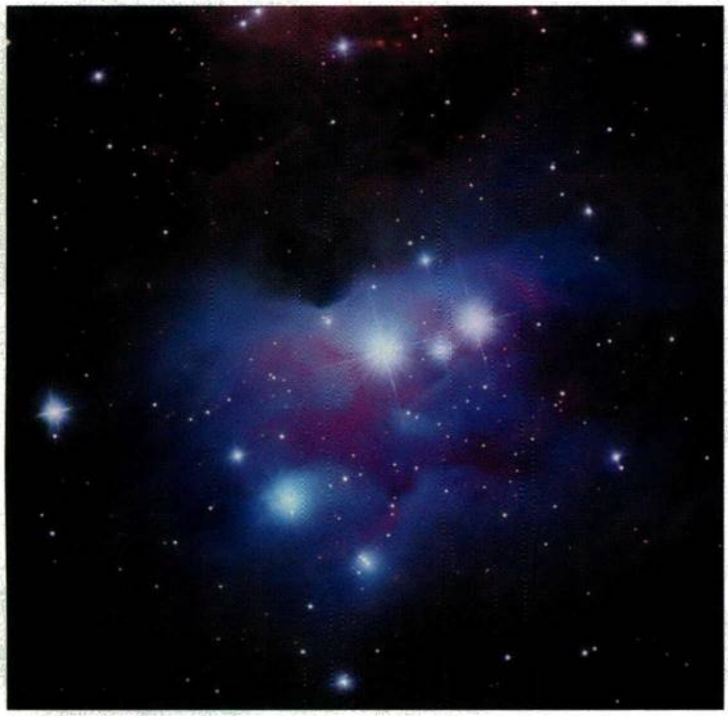
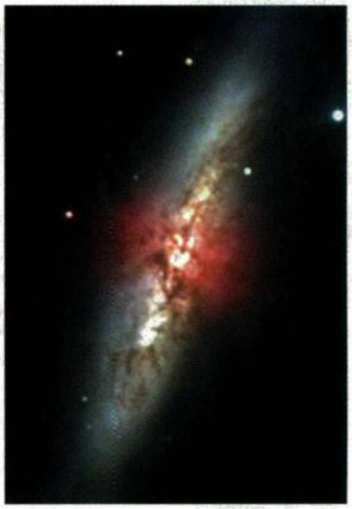
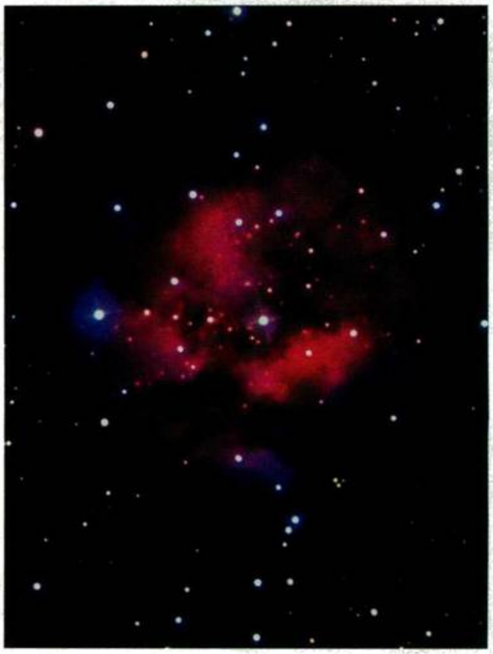






Gendler captured all images on these pages with his 12.5-inch Ritchey-Chrétien scope, from his driveway near Hartford, Connecticut.

Opposite page: NGC 6960, the Veil Nebula, supernova remnant in Cygnus, taken at f/6, composite of four images.

Clockwise from top: M104, the Sombrero Galaxy, taken at f/7; M82, irregular galaxy in Ursa Major, taken at f/9; IC 5146, the Cocoon Nebula in Cygnus, taken at f/6; NGC 1977, emission and reflection nebula in Orion, taken at f/7.5 with an IMG 1024 digital camera.

Spying on the Neighbors

The Magellanic Clouds can teach us a lot about some of astronomy's enduring riddles.

by Paul Hodge

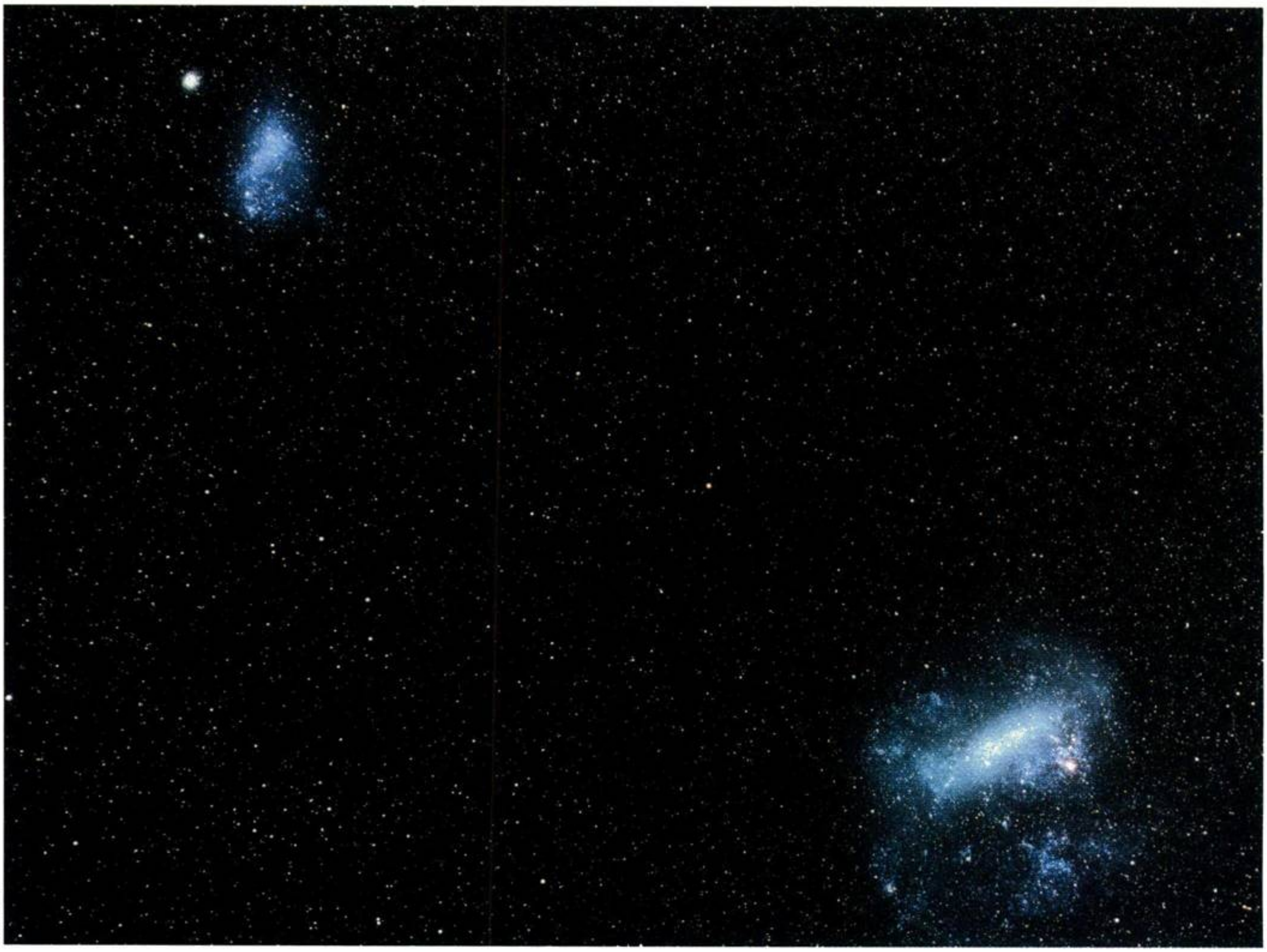
Ever since the early 16th century, when Portuguese explorer Ferdinand Magellan looked to two cloud-like smatterings of starlight for help in navigating the wind-tossed southern seas, the Magellanic Clouds have remained a gateway for scientific explorers of the deep sky.

In fact, the great astronomer Harlow Shapley wrote a classic article in the mid-20th century entitled "The Clouds of Magellan: Gateway to the Universe," which serves as a tribute to our close galactic neighbors and the important role they have played in promoting understanding of celestial phenomena. Many theories have been conceived or laid to rest with observations of "the Clouds" — as the astronomically savvy often refer to them.

The Clouds have also been crucial to helping solve some of the most recent astronomical puzzles. In fact, for the last five years the University of Illinois has sponsored and published a monthly electronic newsletter devoted to information exchange and interdisciplinary collaboration on research solely directed at our Magellanic companions, one of the few deep-sky objects with such a dedicated following. Much of this research has led to revisions in our knowledge of galactic tides, star formation, and the evolution of galaxies.

The Clouds comprise the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC), both of which are very close to us — roughly 180,000 and 205,000 light-years, respectively — as far as galaxies go. They are also very close to each other — about 90,000 light-years. So close, in fact, that the strong gravitational interplay between them has continuously altered their shapes as well as their orbits around our Milky Way Galaxy.

Ring-shaped nebula Henize 70 in the LMC is a "superbubble" of interstellar gas 300,000 light-years wide blown by winds from massive stars and supernovae explosions. ESO



Luke Dodd

Little known to most people of the Northern Hemisphere are the Large (lower right) and Small (upper left) Magellanic Clouds, which purportedly helped Portuguese explorer Ferdinand Magellan navigate stormy southern seas in the early 16th century.

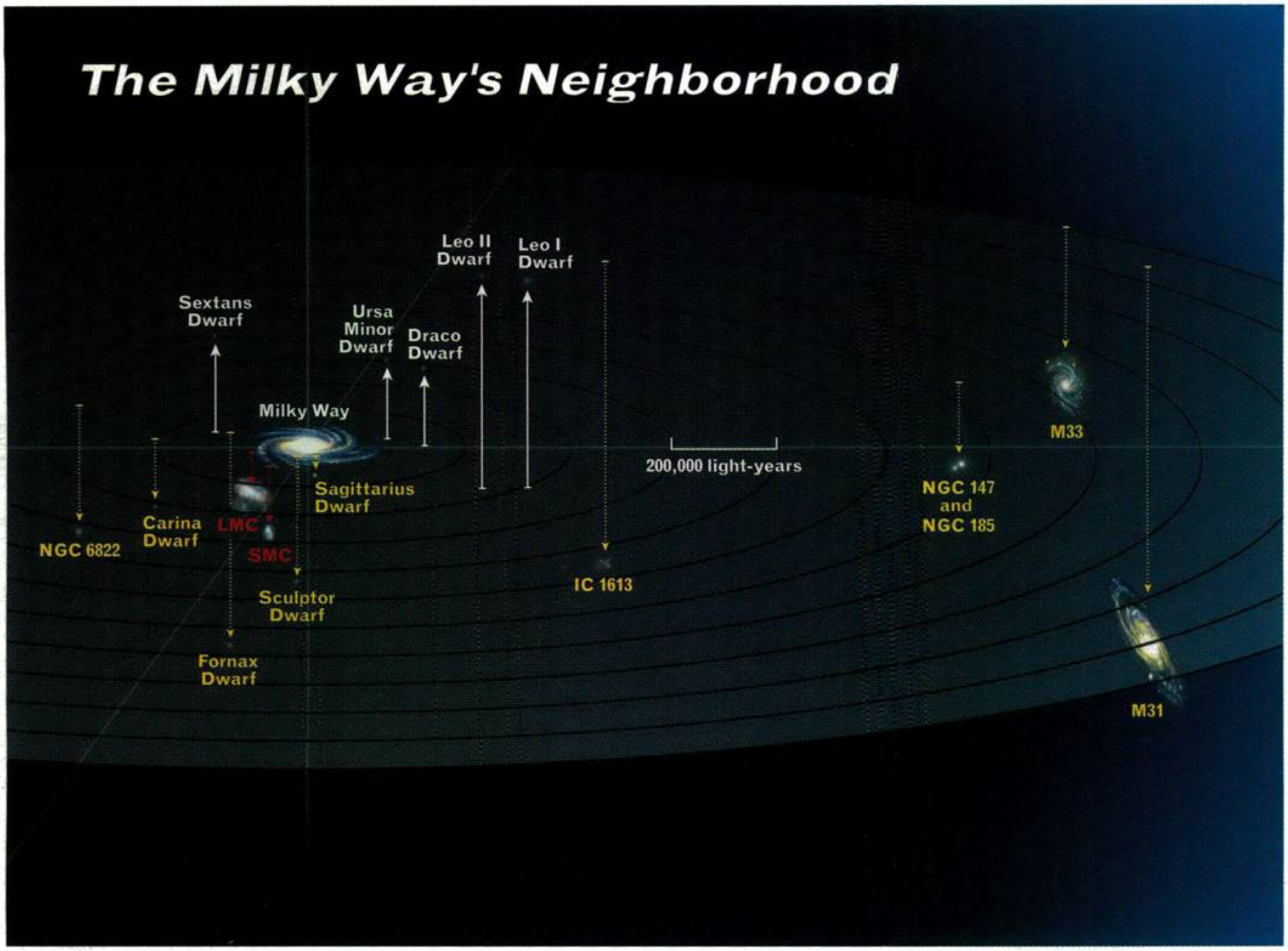
Anyone who has spent time at the seashore knows how tides can change the appearance of a shoreline. More and more clues are turning up that inform us of the strong tidal effects between the Magellanic Clouds and other local galaxies. Some of these tides have been so forceful that they have deeply distorted the shapes of the Clouds. The most famous case is the amazing Magellanic Stream — a great tidal tail resulting from the action of a gravitational tug-of-war between the Milky Way and the Magellanic pair of galaxies. The Stream is a huge arc of hydrogen gas that stretches halfway across the sky. New computer models suggest that this curious structure was initially formed by a close encounter of the three galaxies nearly 1.5 billion years ago.

Other evidence of tidal disturbances within the Clouds includes the stars and gas that are spread like a faintly luminescent bridge between them. Researchers have just recently recognized a sweeping arc of neutral hydrogen gas running from the LMC to the Milky Way, one that some estimate formed during an encounter between the two galaxies just 200 million years ago.

The Milky Way and the Clouds are members of a small congregation of about 35 galaxies referred to as the Local Group. If we were to look at the Local Group from some galaxy far, far away, (see illustration on page 41) we would see two bright spirals (the Milky Way and Andromeda galaxies), a fainter spiral (M33) and several dwarf galaxies. Hugging right close in the vicinity of the Milky Way are the Magellanic Clouds.

Recent mathematical and computer models of tidal interactions within the Local Group suggest that the Clouds moved into our galactic neighborhood not long ago. One such model finds that they probably began life closer to the Andromeda Galaxy. Then, after suffering a close encounter with M31 about 10 billion years ago, the Clouds were slung over to our part of the Local Group, where they are now in their second close approach to the Milky Way.

So how do such gravitational tides work between galaxies? The idea is actually pretty simple, though calculating exactly what happens requires powerful computers. As the galaxies perform their cosmic dance, gravity steps in when one galaxy gets too close to another. Each galaxy feels the overwhelming allure of the other, and they often swap stars during an encounter. Some of these stars will eventually fall back into their progenitor galaxy, while others find themselves in a new galactic home. But many stars get thrown out into space and left as orphans that, collectively, form thin tails between interacting galaxies.



Though separated by seemingly vast distances, members of this local grouping of galaxies participate in an ongoing gravitational dance that constantly alters their shapes and relative positioning. The Magellanic Clouds are labeled in red.

Astronomy: Elisabeth Rowan

In the case of the Magellanic Clouds and the Milky Way, the situation is complicated by the presence of not two, but three galaxies interacting closely enough to form tidal tails and bridges that astronomers have only recently begun to glimpse.

Magellanic Fossil-Hunting

The Clouds contain thousands of star clusters, the biggest of which are referred to as globular star clusters. Because they are usually quite massive, globular star clusters are "dynamically stable," and therefore remain fairly intact over a very long time. Because of this, they may be viewed as astronomical fossils that once analyzed, or "dug up," should help explain the early histories of their host galaxies.

The globular clusters in the Magellanic Clouds have puzzled astronomers ever since the early 20th century when Harvard's Annie Cannon found that many showed quite peculiar spectral signatures. While cooler yellow and red stars dominate the globular clusters in the Milky Way, hot, bluish stars overpopulate the Clouds. By the 1960s, astronomers realized that the latter were young globulars — some only 20 million years old. Up until then, the only globular clusters on record were those in our own galaxy, which are roughly 12 to 15 billion years old.

When these infantile clusters in the Magellanic group were first observed, it was as if paleontologists, digging on some other continent, had come across dinosaur bones with ages right up to the present. In such a situation, it would be a good idea for the scientist to look around to see whether a *T. Rex* might be stomping toward the dig. In the case of the Clouds, there is such a living dinosaur, and it's still forming. It lies in the heart of the LMC, and is known as the Tarantula Nebula (for more information, see "The Tarantula and the Superstars," page 42).

So the Magellanic Clouds have shown off their youthful side, but do they possess elderly clusters? This question has intrigued astronomers for decades, for it would tell us when the Clouds formed in relation to our Milky Way Galaxy. From ground-based telescopes we had identified globular clusters tucked deep inside the Clouds that appeared roughly 10 billion years old, but an accurate age range was hard to estimate because most of these stars were just too faint.

In the late 1990s, however, the Hubble Space Telescope (HST) resolved this dilemma. Working independently, astronomers Knut Olsen at the University of Washington and Jennifer Johnson at the University of California–Santa Cruz showed that a dozen globular clusters in the LMC are

The Tarantula and the Superstars

STScI

The Magellanic Clouds may be small galaxies, but they are by no means quiet. In fact, the LMC is one of the liveliest galaxies known to astronomers, containing the most active stellar nursery in the nearby universe. Known more familiarly as the Tarantula Nebula and listed in the catalogs as 30 Doradus ("30 Dor" for short), this amazing cloud of gas, dust and explosive starbirth has no known equal anywhere in our galaxy. With filaments of gas extending out almost 1,000 light-years, 30 Dor is so bright that it's visible with the naked eye, and it's 180,000 light-years away!

The most remarkable part of the Tarantula Nebula has only recently been revealed. Buried in the heart of this arachnid-like structure is an extremely bright object, originally thought to be a single massive star, catalogued as R136. Even with giant Earth-based telescopes, pictures of R136 appear as little more than a bright blue blur. However, some pre-HST studies using interferometry, which can disentangle structure if a source is bright enough, resolved it into eight individual stars, all extremely luminous and packed into a volume only 25 light-years across.

New HST data reveal even more about what's in the Tarantula's curious holdings. There are hundreds of young stars in this just-born cluster and 40 of them are of spectral type O3, a rare type of extremely hot star found in just a few places in our Milky Way. There are more of these stellar beasts locked in the Tarantula's clutches than exist in our entire galaxy. And they are, indeed, beasts, each about 100 solar masses. They are very young too, only a million years old or less with some new stars still forming among them. With no counterpart in our cosmic neighborhood, this LMC substructure is giving many clues to astronomers puzzling over star formation.

ancient, around 14 billion years old, essentially the same age as the oldest cluster in the Milky Way. So we are confident that the LMC formed about the same time as our Galaxy.

But the SMC is an entirely different story; it holds only one significantly old cluster — NGC 121. This cluster is an estimated 11 billion years old, and is bright enough to be seen with even a moderately small telescope. The other "old" globulars in the SMC are much younger — perhaps some as old as only a few billion years.

Given these age discrepancies, one would like to think that the SMC formed quite a bit later than the LMC and the Milky Way. However, it is important to keep in mind that the SMC is a very small galaxy and may not have been able to attract enough raw materials to form massive clusters early on. HST studies of field stars in the SMC have revealed the presence of some old stars, but the question remains just how old.

Living in a Strange Galaxy

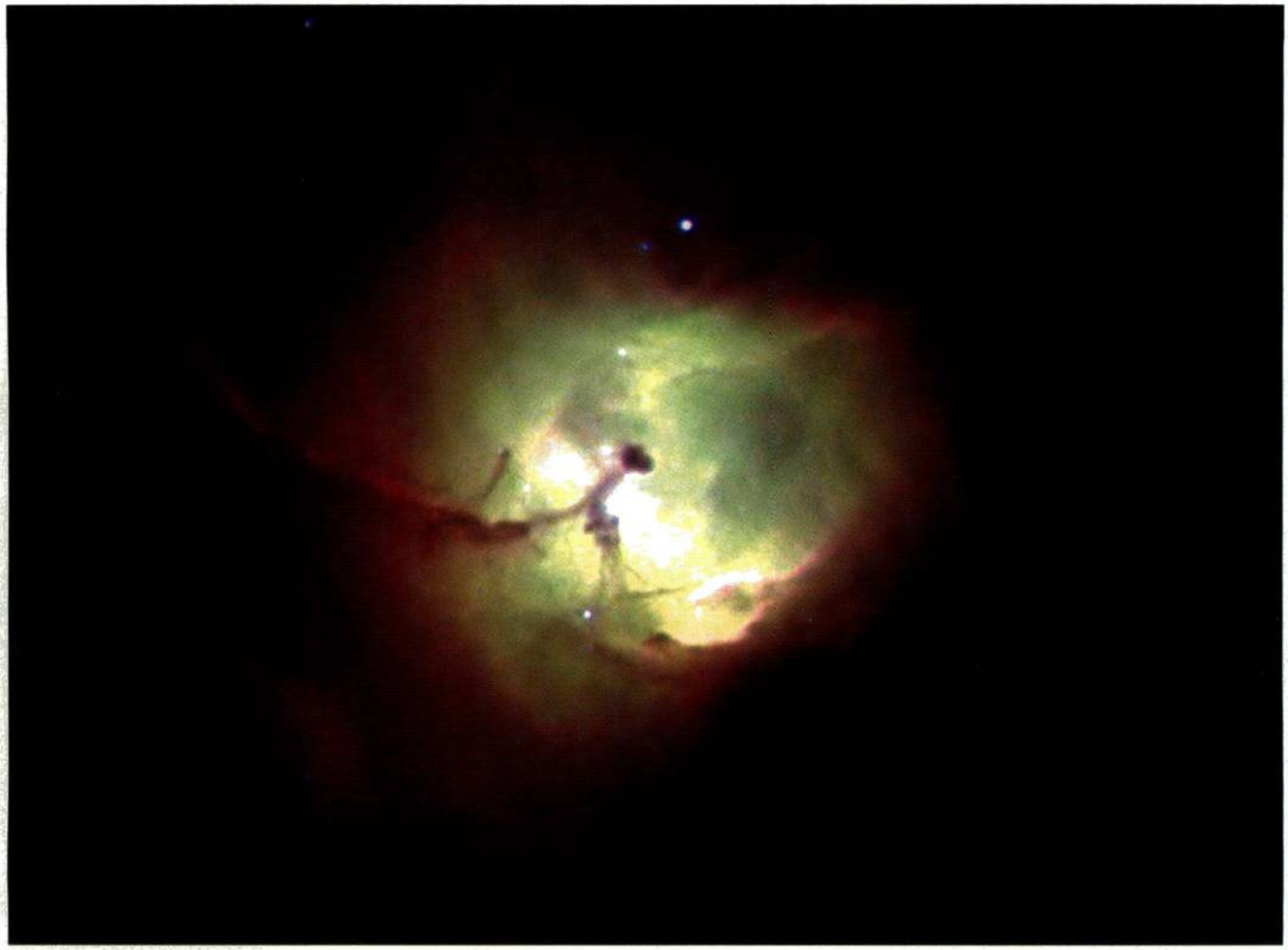
We now know the ages of the oldest star clusters in the Clouds, but a puzzle still remains: Why do the Clouds have globular-like star clusters that are both young and old, while the Milky Way Galaxy has only elderly clusters?

A new finding elsewhere in the universe has shed some light on this seeming puzzle. Apparently, the Magellanic Clouds are more the norm; it's our own galaxy that's the oddball. A recent survey of spiral galaxies by the Danish astronomer Soeren Larsen has shown that massive young clusters are fairly common in these galaxies. One example is a huge cluster in the beautiful spiral galaxy NGC 6946. This cluster is only about 15 million years old, but 50 times brighter than the most luminous globular clusters in the Milky Way. Furthermore, this cluster is surrounded by a ring of smaller young clusters, which are arranged in a nearly perfect circle.

Listen to Thy Neighbor

How stars form in galaxies — what astronomers have dubbed the "mode" of star formation — then, generally includes spectacular events involving huge masses of gas and dust that build up into giant globular clusters. Our galaxy did this back around the time it formed, but never since. And to this we still have no answers. But meanwhile, Andromeda (M31), a more massive galaxy, is still forming massive clusters, though smaller than those of the Magellanic Clouds or, certainly, the huge cluster in NGC 6946.

Theoreticians who attempt to understand the details of stellar evolution are grateful for the

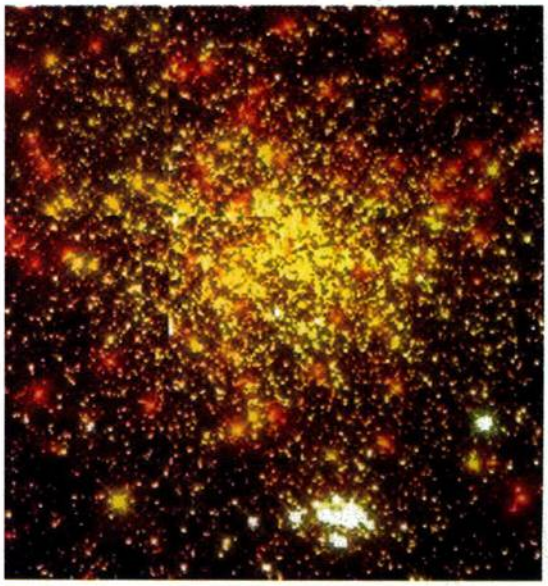


Hubble Heritage/NASA

Magellanic globular clusters. Because our galaxy's clusters are all in their senior years, they're not much help in testing theoretical models of the evolution of stars at different points in the stellar life-cycle. However, the Clouds are close enough and endowed with clusters of so many different ages that they provide rich samples for researchers studying stellar evolution.

For example, rich young clusters in the Clouds help us understand how much mass is lost by giant stars due to their stellar winds. Also, studies of a cluster's faintest stars show how many low-mass stars are formed relative to the number of high-mass stars. A recent HST study of the young LMC star clusters NGC 1805 and NGC 1818, both of which are about 40 million years old, indicates that one formed with a higher percentage of massive stars than the other did. We don't know why they differ yet, but it likely depends on the conditions in the pre-cluster cloud — a topic that promises to keep astronomers scratching their heads for years to come.

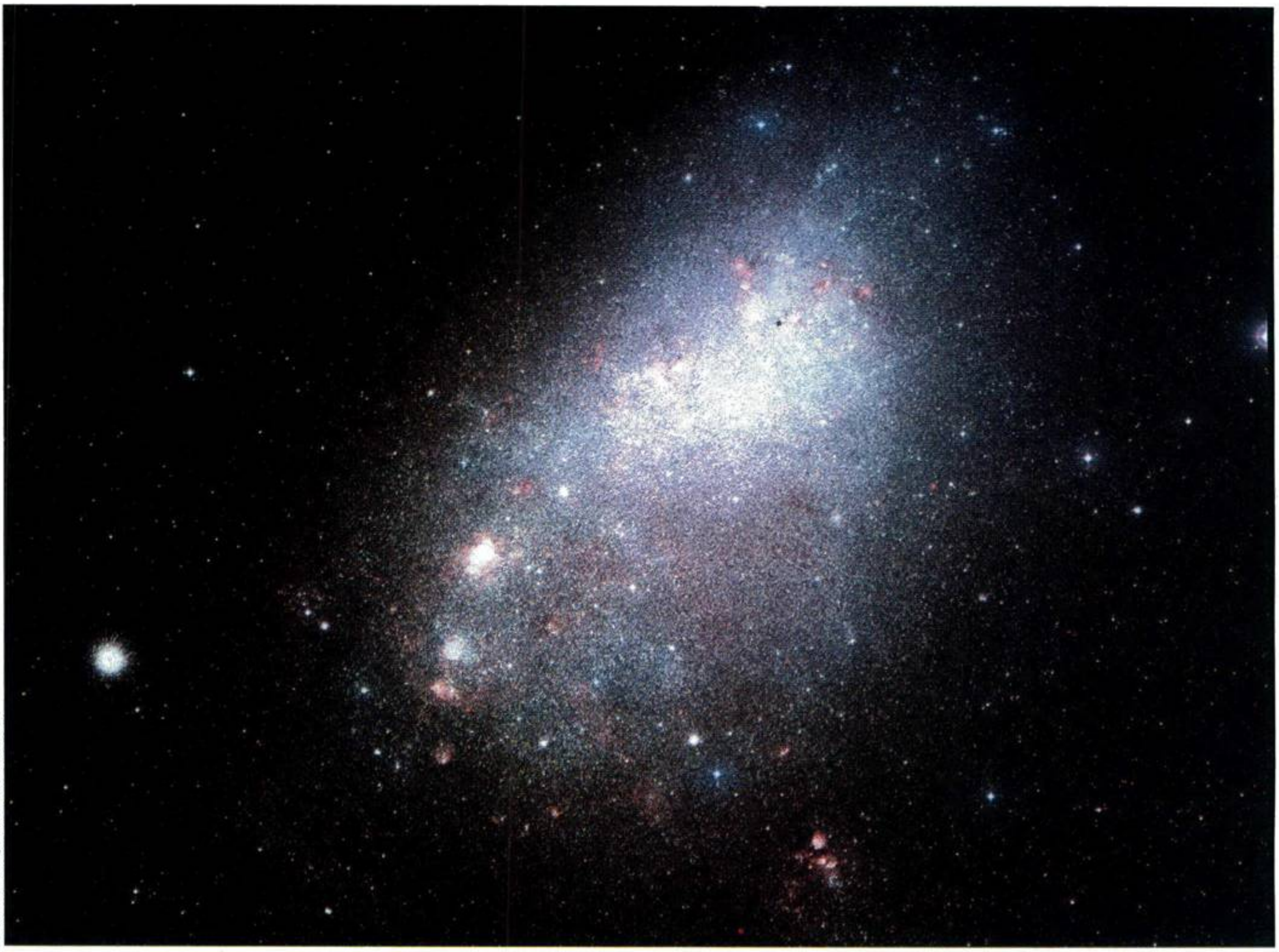
Another opportunity for learning about stellar evolution lurks among the Clouds: the small cluster in the LMC known as HS 327. This tightly knit stellar community has been found to contain both a carbon star and a so-called hydroxyl star — a very cool giant with lots of hydroxyl (OH) in its atmosphere. The two stars, born in the same cluster and having recently evolved from the Main Sequence (where stars spend most of their lifetimes), must have had the same initial mass. But the OH stars somehow skirted becoming carbon stars, a curiosity that, once understood, may give theoreticians a grasp on how massive stars evolve.



NASA

Above: The birth of a cluster of massive stars in their natal nebula — cataloged as N81 in the SMC.

Left: The large star cluster NGC 1850 in the LMC. Yellowish stars are sunlike main sequence stars about 50 million years old, while the whiter stars are massive, hotter, and younger about 4 million years old.



David Malin/Anglo-Australian Telescope

The SMC foils astronomers who'd like to nail down its history — it holds an older star cluster similar in age to most clusters in the LMC, but it also packs a preponderance of freakishly young globulars.

A Celestial YMCA

Young Magellanic Cloud Associations (YMCAs) are among the most-studied objects in the Clouds. They provide even more information about the processes of star formation. Most YMCAs are similar to the Milky Way's OB associations — so-called because of the preponderance of young massive blue stars of spectral types O and B — such as the giant one that occupies most of the constellation Orion. Because radiation from such hot stars often concentrates in the ultraviolet portion of the electromagnetic spectrum, astronomers have carried out extensive observations of YMCAs with ultraviolet space telescopes, such as the famous IUE (International Ultraviolet Explorer) and the more recent UIT (Ultraviolet Imaging Telescope).

OB associations are very satisfying to study; they demonstrate how super-dense clouds often form into star clusters, which often disperse to form even larger complexes of stars. Scientific consensus holds that all stars originally form in such loose associations, and then only a few of these clouds become dense enough to shape into stable star clusters. An OB association often remains recognizable for only a few million years until its stars gently migrate from the core of the association to mingle with stars in the field.

One puzzling fact about OB associations is related less to stars within them than those not in them. A good example is a recent UIT study of a very active region of the LMC that includes three YMCAs (OB associations) — LH2, LH5 and LH8. Ultraviolet images of this region show YMCAs quite clearly and confirm ground-based observations about their ages and stellar content. But also seen are many O and B stars that lie in between the associations, that is, orphaned to the general field. How these stars could form out there all by themselves is curious. As we understand it, stars like this must form while enveloped in a cloud of gas and, especially, dust, which is necessary to cool the system as stars take shape. So how do these massive, young stars exist so far from any obvious stellar birthplace? Since these solo stars are too far from YMCAs to have once been ejected from them, an important question comes to the fore: Is it possible for single stars to form in isolation? It's too early to say, but future ultraviolet studies of the YMCAs may help us answer this.

Gas-Rich and Dust-Free

Interestingly, even though we now know that the Clouds are galaxies, they do indeed contain clouds. In fact, they contain hundreds of glowing gas clouds, and even more that faintly

David Malin/Anglo-Australian Telescope

show up as dark nebulae. And we have recently detected yet other kinds of clouds within the Clouds, many of which are invisible at optical wavelengths. Using millimeter-sensitive telescopes, such as the giant ESO Submillimeter Telescope at La Silla in Chile, we have spotted these stealthy clouds packed with cool gas, especially carbon monoxide and molecular hydrogen. These clouds are also fainter and less smooth in their gas distribution than those found in our Milky Way. These differences may be related to the lower heavy element abundance found in the Magellanic grouping or to different modes of star formation, or quite possibly both.

While there is abundant gas throughout both galaxies, there is little dust in the Clouds. Adding to this fact, dust clouds are notoriously difficult to detect. But far-infrared observations, such as those made with the Infrared Astronomical Satellite (IRAS) — a joint project of the U.S., U.K. and the Netherlands — and the ESA's Infrared Space Observatory, allow us to peer into at least some of our neighbors' dusty molecular clouds, which show less dust mass than otherwise similar clouds in our galaxy. This result is probably related to the lower heavy element abundance in the Magellanic Clouds — dust is largely made of heavier elements (heavier than hydrogen and helium, which makes up most of the gas) and where there's less of these elements, there's less dust.

So given this variation in cloud composition, the Clouds may provide fruit for astronomers who want to understand how things develop under different environmental conditions — something we can't learn from studying our home galaxy alone.

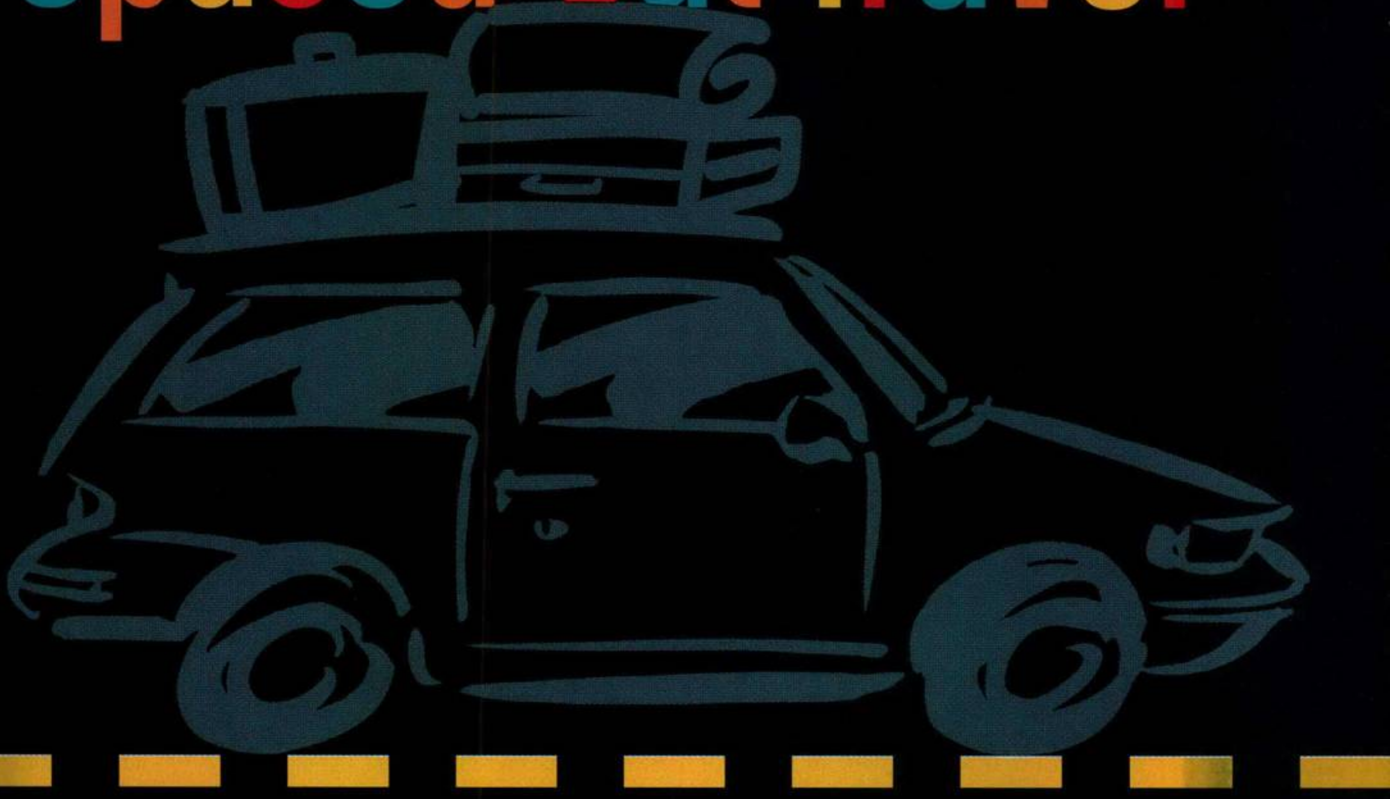
Truly a Gateway?

Was Harlow Shapley right when he called the Clouds of Magellan the "Gateway to the Universe?" Most astronomers who have explored these close galactic neighbors would have to agree. The Clouds' features provide a close-up view of the remarkable effects of tidal encounters between galaxies. Their ages help establish a timeline of formation of other local galaxies, and their remarkably active clouds of gas provide us with wonderful examples of nature's boldest efforts at making stars. They also tell us things about processes that we cannot observe here in the Milky Way and other neighboring galaxies. ◼

Paul Hodge is professor of astronomy at the University of Washington and acting editor of the Astronomical Journal. *His research is primarily in the field of galaxies and star formation, but he also studies meteoritic craters.*

After probing deep into the LMC, astronomers have encountered a few stellar puzzles — such as hot, massive stars that seemed to have formed in isolation and a pair of stars with otherwise similar pedigrees that have followed divergent evolutionary paths.

Spaced-out Travel



From sea to shining sea, there's a place for every astronomy lover to explore.

by Kelly Kizer Whitt

Planning the family's summer vacation once again and trying to avoid the amusement park rut? We've got good news and bad news. First the good news — 50 fabulous places in America designed for the astronomy-minded tourist follow. With museums, planetaria, observatories, meteorite craters, and more scattered across the country, you're sure to find a place the whole family will enjoy. The bad news? Because we cut off at 50, we couldn't include everything. So the Hubble Space Telescope replica on the courthouse lawn of Edwin Hubble's hometown in Marshfield, Missouri, the Extraterrestrial Highway in Nevada, and other worthy sites that didn't make the list are left out, waiting for another time. Enjoy!

ALABAMA

① Huntsville

U.S. Space and Rocket Center
One Tranquillity Base
Zip: 35807–7015
Phone: (205) 837–3400
Website: http://www.spacecamp.com/museum

The U.S. Space and Rocket Center includes three separate sections, the museum and center, space camp, and aviation challenger. California and Florida have similar space camp facilities connected to NASA, but only in Alabama are there programs exclusively for adults. The grounds also house the largest collection of rockets in the world, rides, and an IMAX theater.

ALASKA

② Fairbanks

University of Alaska, Poker Flat Research Range
30 miles north of Fairbanks on the Steese Highway
Phone: (907) 474–7942
Website: http://www.pfrr.alaska.edu/pfrr/INDEX.HTM

About once a week during the summer you can catch a tour of PFRR, including a visit to the rocket launch area, Lidar Observatory, and the climate change monitoring station. Although not open for tours in the winter, it's still a great area for viewing the northern lights.

ARIZONA

③ Flagstaff

Lowell Observatory
1400 Mars Hill Road
Zip: 86001
Phone: (520) 774–3358
Website: http://www.lowell.edu

For a small admission fee, Lowell Observatory opens its doors for day and night adventures. Depending on which time of day you choose, you can enjoy solar or nighttime observing through their large telescopes, sit in on a lecture, see the famous Alvan Clark 24-inch refractor, and tour the Slipher Building Rotunda featuring Lowell's original maps of Mars. On the grounds you'll find the Pluto Walk, a scale model of our Solar System, and Pluto Dome, the original structure and 13-inch telescope used to discover Pluto. Percival Lowell's elaborate mausoleum is also on site.

④ Safford

Discovery Park, Gov. Aker Observatory
1651 West Discovery Park Blvd
Zip: 85546
Phone: (520) 428–6260
Website: http://www.discoverypark.com

In a quiet southeastern corner of Arizona sits Discovery Park, home to the world's largest known Camera Obscura. In addition, the park houses a 20-inch optical telescope and a state-of-the-art space simulator ride, the "Shuttlecraft Polaris." See how craters are blasted onto the moon, sit in on a class on astronomy's link to mythology, or catch a tour of Mount Graham International Observatory beginning from their visitor's center.

⑤ Tucson

Kitt Peak Observatory
56 miles southwest of Tucson, route 386
Phone: (520) 318–8000
Website:
http://www.noao.edu/kpno/kpno.html (Virtual Tour Available)

On the Tohono O'odham Reservation, at the summit of Kitt Peak, you'll find 22 optical and two radio telescopes. The visitor's center offers guided tours (small donations requested) and a more extensive nightly observing program can be arranged for a moderate fee.

⑥ Winslow

Barringer Meteor Crater
West of Winslow on I–40, exit 233
Phone: 1 800 289–5898
Website: http://www.meteorcrater.com

Much more than just a hole in the ground (and an amazing one at that), the Meteor Crater site offers the Museum of Astrogeology; Astronaut Hall of Fame; Astronaut Memorial Park; daily guided rim tours; a new, state-of-the-art, 80-seat wide-screen movie theater; a 1,406-lb. meteorite, and a gift shop.

CALIFORNIA

⑦ Los Angeles

Griffith Observatory
2800 East Observatory Road
Zip: 90027–1255
Phone: (323) 664–1191
Website: http://www.griffithobservatory.org

Besides offering a piece of history and the best view of the L.A. valley, Griffith Observatory pleases the starry-minded tourist with its Hall of Science astronomy museum, telescopes for daily and nightly observing (weather permitting), and planetarium theater.

⑧ Mount Hamilton

Lick Observatory
Mount Hamilton Road, Route 130
Phone: (831) 459–2513
Website: http://www.ucolick.org (Virtual Tour Available)

The University of California's telescopes are located 20 miles outside San Jose. You can visit the area during the day, but no evening visitors are allowed except during specific scheduled public viewing events on Friday and Saturday summer nights (contact Lick for more information). In addition, Lick offers the Music of the Spheres, a series of summer concerts held in the Great Hall followed by lectures given by Lick Observatory astronomers and viewing through one of the telescopes.

⑨ Oakland

Chabot Space and Science Center
10000 Skyline Blvd.
Zip: 94619-3014
Phone: (510) 336–7300
Website: http://www.cosc.org

Watch a planetarium presentation, view the heavens through 8- and 20-inch refractors, sign up for a mission at the Challenger Learning Center, get into a telescope makers' workshop, and then refuel yourself at the Celestial Cafe before exploring the many exhibits.

⑩ San Diego

Balboa Park: Reuben H. Fleet Space Theater and Science Center, San Diego Aerospace Museum
1875 El Prado Balboa Park
Zip: 92163–3303
Phone: (619) 238–1233
Website:
http://www.rhfleet.org

Spend a day at Balboa Park to witness a stunning planetarium show, explore the Meteor Storm exhibit, partcipate in a SciTour simulation of a comet on a collision course with Earth, attend an astronomy lecture, or find an educational gift at the science store.

⑪ San Francisco

California Academy of Sciences: Morrison Planetarium, Natural History Museum
55 Concourse Drive
Golden Gate Park
Zip: 94118
Phone: (415) 750–7141
Website: http://www.calacademy.org

Besides a fabulous planetarium, you can also find frequent astronomy lectures and concerts here. Their website offers information on what you can see in the sky each night.

⑫ San Francisco

Exploratorium Observatory
3601 Lyon Street
Zip: 94123
Phone: 415–EXP–LORE
Website: http://www.exploratorium.edu/index.html

The exploratorium's changing exhibits have recently included "Hubble: A View to the Edge of Space" and a live webcast of the African eclipse. The observatory's most recent theme featured the sun, detailing sun spots, aurorae, the Mercury transit, eclipses, and more.

COLORADO

⑬ Boulder

Fiske Planetarium
Regent Drive
Zip: 80309
Phone: (303) 492–5002
Website: http://www.colorado.edu/fiske (Virtual Tour Available)

Sit in on a "star talk" presented by a CU astronomer, or take part in a workshop, lab, or observing session. "Starshows" range in topics from Mars Quest, to Cosmic Collisions, to Searching for Distant Worlds, and more.

CONNECTICUT

⑭ Bridgeport

Discovery Museum, Challenger Learning Center
4450 Park Avenue
Zip: 06604
Phone: (203) 372–3521
Website: None

The museum has daily planetarium shows, changing science exhibits, and a learning center that can be reserved for mini-missions or 5-hour sessions.

FLORIDA

⑮ Cape Canaveral

Kennedy Space Center Visitor Complex
U.S. Highway 1
Zip: 32899
Phone: 1–800–572–4636
Website: http://www.kennedyspacecenter.com

Where else can you view a shuttle launch or landing and a 3D IMAX movie about space? Only an hour east of Orlando, much more awaits visitors to the Kennedy Space Center, including the Air Force Space Museum, Astronauts Memorial, U.S. Astronaut Hall of Fame, U.S. Space Camp, and Rocket Garden, to name a few.

⑯ Cocoa Beach

Astronaut Memorial Planetarium and Observatory
1519 Clearlake Rd
Phone: (321) 632–1111
Website: http://www.brevard.cc.fl.us/~planet (Virtual Tour Available)

You can pay a small fee for a planetarium show or movie, but the observatory, International Hall of Space Explorers, and Exhibit Hall are free.

⑰ Tampa Bay

Museum of Science and Industry
4801 E. Fowler Ave.
Phone: (813) 987-6000
Website: http://www.mosi.org

The Saunders Planetarium will probably be the first stop on your list at this museum, but be sure to check out some of their permanent exhibits, including a Challenger Learning Center and Our Place in the Universe. And for a moderate fee, you can learn how to use that telescope that has been in your attic for years with Private Telescope Tutoring.

HAWAII

⑱ The Big Island

Mauna Kea Observatories Onizuka Center for International Astronomy (OCIA) Visitor's Information Station
Route 20/Saddle Road
Phone: (808) 961–2180
Website:
http://www.ifa.hawaii.edu/mko

⑲ The Big Island

Onizuka Space Center
Kona International Airport
Phone: (808) 329–3441
Website: http://planet-hawaii.com/astronautonizuka

On the Big Island of Hawaii, two spots for astronomy enthusiasts are named for Ellison S. Onizuka, Hawaii's first astronaut, who perished in the Challenger explosion. At the Kona International Airport is the Onizuka Space Center, which includes exhibits about astronauts, the space shuttle, and Mir. A space theater is also on the premises. Toward the center of the island on Route 20 sits the visitor's center for the many telescopes of the Mauna Kea Observatory. You can use your own four-wheel drive vehicle to make the ascent to the top if you follow their many restrictions and guidelines. There are visitor galleries at the University of Hawaii and Keck I telescopes. Public observing is held at the visitor center.

ILLINOIS

⑳ Chicago

Adler Planetarium and Astronomy Museum
1300 S. Lake Shore Drive
Zip: 60605
Phone: (312) 922–STAR
Website: http://www.adlerplanetarium.org

With the distinctive title of the first planetarium in the Western Hemisphere, Adler has a "StarRider Theater" and a sky theater, which, unlike other theaters, focuses just on astronomy presentations. Observing, lectures, and exhibits round out the "to-do" list at the museum.

㉑ Chicago

Museum of Science and Industry
57th Street and
Lake Shore Drive
Zip: 60637
Phone: 1–800–GO TO MSI
Website: http://www.msichicago.org

Visit their website to explore the online exhibit of the space station, or visit them in person to check out their ever-changing exhibits. Some of the permanent astronomy-related exhibits include: Apollo 8 Command Module, The Lunar Module, Mercury Space Capsule, and The Henry Crown Space Center Omnimax Theater with changing shows, sometimes space related, sometimes not.

㉒ Peoria

Lakeview Museum of Arts and Sciences
1125 West Lake Avenue
Zip: 61614
Phone: (309) 686–7000
Website: http://www.midil.com/a1/artsfnd/paasc/lakeview.html

Spend an afternoon in Peoria learning from the art and science exhibits, children's Discovery Center, planetarium, and the Guinness Book of World Records world's largest solar system model.

㉓ River Grove

Cernan Earth and Space Center
Triton College
2000 Fifth Avenue
Phone: (708) 456–0300 ext. 3372
Website: http://www.triton.cc.il.us/cernan/cernan_home.html

Illinois native and last man on the moon, Eugene A. Cernan, is honored by the facility at Triton College in the Chicago suburbs. Exhibits about Apollo, telescopes, space exploration, and more reside in the main lobby. The dome theater features planetarium and other shows.

INDIANA

㉔ Indianapolis

SpaceQuest Planetarium
The Children's Museum of Indianapolis

3000 North Meridian Street
Zip: 46208–4716
Phone: (317) 924–5431
Website: http://www.childrensmuseum.org/index2.htm

In addition to "what's in the sky" shows, the planetarium has other informational shows. Recent presentations include Skywatchers, about celestial mysteries; Startales, about Native Americans and their observing history; and Hubble's Greatest Hits.

KANSAS

㉕ Hutchinson

Kansas Cosmosphere and Space Center
1100 North Plum
Zip: 67501–1499
Phone: (316) 662–2305 / 1–800–397–0330
Website: http://www.cosmo.org

The Center illustrates the history of the space race between the former USSR and the United States, including the current cooperation that is helping to build the International Space Station. The most impressive artifact on site is the Apollo 13 command module "Odyssey," whose journey was documented in the hit movie *Apollo 13*. Other astronomy attraction staples, such as an IMAX and planetarium, also reside here.

LOUISIANA

㉖ Baton Rouge

Challenger Learning Center/The Louisiana Arts & Science Center
100 South River Road
Zip: 70802
Phone: (504) 344–5272
Website: http://www.lascmuseum.org/clc

As one of the many Challenger Learning Centers across the nation, the facilities are geared for schools, but the public can reserve a "flight" on the weekends on the Space Lab simulator. Fourteen to 16 people are needed to fill the class and there are three missions from which to choose.

MARYLAND

㉗ Greenbelt

NASA Goddard Space Flight Center
Greenbelt Road (Main Gate)
Zip: 20771
Phone: (301) 286–2000
Website: http://www.gsfc.nasa.gov (Virtual Tour Available)

The public can tour this working facility including NASA's communications network and the control center for the Hubble Space Telescope. Tours are available Monday through Saturday; the minimum age requirement is 10 years. Exhibits and presentations are also on site. Admission and parking are free.

MASSACHUSETTS

㉘ Boston

Museum of Science: Hayden Planetarium and Gilliland Observatory Science Park
O'Brien Highway (Rt. 28)
Zip: 02114-1099
Phone: (617) 723–2500
Website: http://www.mos.org

A unique interactive planetarium and observatory on the roof of their parking garage brings the stars to the public in innovative ways. View through the scopes on Friday nights or see live images from space transmitted to the planetarium dome during a show.

MICHIGAN

㉙ Jackson

Michigan Space and Science Center
2111 Emmons Road
Zip: 49203
Phone: (517) 787–4425
Website: None

Relive the innovation and monumental first steps made in space flight with authentic artifacts from the U.S. space program under this huge geodesic dome.

MISSISSIPPI

㉚ Stennis Space Center

Stennis Space Center
Hwy 607
Zip: 39529
Phone: (601) 688–2370 or 1–800–237–1821
Website: http://www.ssc.nasa.gov

Designated as a federal city, Stennis Space Center is where NASA tests its rockets. If you're lucky you might be there on a day when they perform a test for flight-worthiness. Many scale-model space vehicles are on exhibit along with some genuine rockets used to power the first American satellite into space. After a tour you can watch an educational film on space or partake in some of the interactive exhibits. The best part: There is no admission charge.

MISSOURI

㉛ St. Louis

St. Louis Science Center
5050 Oakland Avenue
Zip: 63110
Phone: (314) 289–4400 or 1–800–456–SLSC
Website: http://www.slsc.org

The James S. McDonnell Planetarium celebrated its grand opening in the summer of 2001, and now visitors can revel in the state-of-the-art facility in a new building called the Boeing Space Station. Spend some time at the "Star Bridge" area, where there are exhibits on space, space exploration, and space station work. General admission is free; parking and IMAX tickets are not.

NEVADA

㉜ Reno

Fleischmann Planetarium and Science Center
MS 272, University of Nevada
Zip: 89557–0012
Phone: (775) 784–4812
Website: http://planetarium.unr.nevada.edu/index.html

Fridays in Reno offers free observing through the center's 14-inch telescope. Shows in the StarTheater are all double features; the first show is cosmos-related, while the second show's topic varies. It also has a small museum called the Hall of the Solar System and the website offers information on satellite viewing.

NEW MEXICO

㉝ Alamogordo

The Space Center
Hwy 2001
Zip: 88311–0533
Phone: (505) 437–2840
Website: http://www.zianet.com/space

In the state where modern rocketry took shape, you can find The Space Center, featuring the International Space Hall of Fame, Clyde W. Tombaugh IMAX Dome Theater and Planetarium, and Astronaut Memorial Garden. Their online publication, called CyberSpaceLog, is an electronic version of their print Space Log.

㉞ Socorro

National Radio Astronomy Observatory
Very Large Array
Very Long Baseline Array
Hwy 60
Zip: 87801
Phone: (505) 835–7240
Website: http://www.aoc.nrao.edu/AOC (Virtual Tours Available)

If you want to see where Jodie Foster listened to an incoming message from outer space in the movie *Contact*, take a drive to Socorro. The facility holds a visitor center and has a self-guided walking tour. You are welcome to photograph anything you see.

NEW YORK

㉟ New York City

Rose Center for Earth and Space, Hayden Planetarium
Central Park West at

79th Street
Zip: 10024–5192
Phone: (212) 769–5100
Website: http://www.amnh.org/rose

Catching a planetarium show or educational film, walking a timeline of our universe, or exploring interactive exhibits explaining how the "stuff" of the cosmos was created are just a few ways you can spend the day at this huge museum.

NORTH CAROLINA

㊱ Chapel Hill

Morehead Planetarium University of North Carolina at Chapel Hill
Franklin Street
Zip: 27599
Phone: (919) 962–1236
Website: http://www.unc.edu/depts/mhplanet

Bring the family to experience UNC's Star Theater or observe through its 24-inch Cassegrain telescope. On the grounds you will also find a massive sundial, art galleries, and the Infinity gift shop.

OHIO

㊲ Cleveland

NASA Glenn Research Center
21000 Brookpark Rd.
Phone: (216) 433–4000
Website: http://www.grc.nasa.gov

It may be the best bargain in Ohio. With no admission charge, you can spend the day at the Visitor's Center of the Glenn Research Center. Explore the 8,000 square feet of exhibit space covering topics such as John Glenn (of course) and space communications. One unique feature is the amateur radio club that operates a satellite station on site.

㊳ Columbus

COSI SPACE
333 W. Broad St.
Zip: 43215
Phone: (614) 228–COSI or 1–888–819–COSI
Website: http://www.cosi.org

In case you or your kids weren't around in the sixties to experience the excitement of the dawning of the space age firsthand, you can live (or relive) it now. Inside Columbus's Center of Science and Industry is an exhibit called SPACE with a vintage era living room set where you can watch footage from old news reels of the historic moments. In addition, simulators allow you to pilot the space shuttle or steer a space probe.

㊴ Wapakoneta

Neil Armstrong Air and Space Museum
500 South Apollo Drive, I–75 exit 111
Phone: 419–738–8811 or 1–800–BUCKEYE
Website: http://www.artcom.com/museums/vs/mr/45895.htm

With a theater and photo gallery, in addition to space suits worn by Armstrong, a moon rock from his Apollo 11 mission, and actual aircraft that he flew, the museum is a tribute not only to Armstrong but to his colleagues. More astronauts hail from Ohio than any other state — 23 space travelers so far, including the first man to walk on the moon, Neil Armstrong; the first American and now oldest man in space, John Glenn; and the second woman in space, Judith Resnik, who tragically lost her life in the *Challenger* explosion.

OREGON

㊵ Bend Area

Pine Mountain Observatory
Hwy. 20, turn onto the dirt road after the abandoned gas station (I'm not kidding!)
Zip: 97405
Phone: (541) 382–8331
Website: http://pmo-sun.uoregon.edu (Virtual Tour Available)

This working observatory operated by the University of Oregon welcomes the public to come observe through some of the largest telescopes in the Pacific Northwest. Situated 26 miles southeast of Bend, Oregon, the secluded location provides inky dark skies but not many amenities. Camping is available across the street.

㊶ Eugene

The Eugene, Oregon, Scale Model Solar System
Alton Baker Park
Website: www.efn.org/~jack_v

Originally created by Jack Van Dusen to teach his son to realistically compare the sizes of the planets, his models of the sun, nine planets, and Earth's moon are now on permanent display in the park. The sun (a 4- foot 6-inch sphere) and the terrestrial planets plus the moon are within the boundaries of Alton Baker Park. Spread along the Willamette River's bike path out to a distance of 3.66 miles are the gaseous planets and finally the ⅒ of an inch sphere that denotes Pluto.

TEXAS

㊷ Fort Davis

McDonald Observatory
Hwy. 118
Zip: 79734-1337
Phone: (915) 426–3640
Website: http://www.as.utexas.edu/mcdonald/mcdonald.html (Virtual Tour Available)

Every day you can catch a guided tour, starting at the visitor's center, for a small fee. Or for free you can guide yourself across the grounds. Solar viewing is available daily and celestial viewing occurs three nights a week. Check the online schedule for special events.

㊸ Houston

Space Center Houston, Visitor's Center for Johnson Space Center
1601 NASA Road 1
Zip: 77058
Phone: (281) 244–2105
Website: http://www.spacecenter.org

Take a NASA Tram Tour for a look behind the scenes at the Space Center, including laboratories and mission control. Its theater has a five-story screen for movies that will take you on a journey through space. Try on a real space helmet, touch a moon rock, and walk in space in their simulator. Watch a show in Texas's largest IMAX theater (and in Texas, that must mean it's BIG). For a little more than the price of a movie ticket you can spend the day exploring.

㊹ Odessa

Odessa Meteor Crater
Brochures at the Chamber of Commerce, 700 Grant St.
West on I–20, take the FM 1936 Exit
Website: None

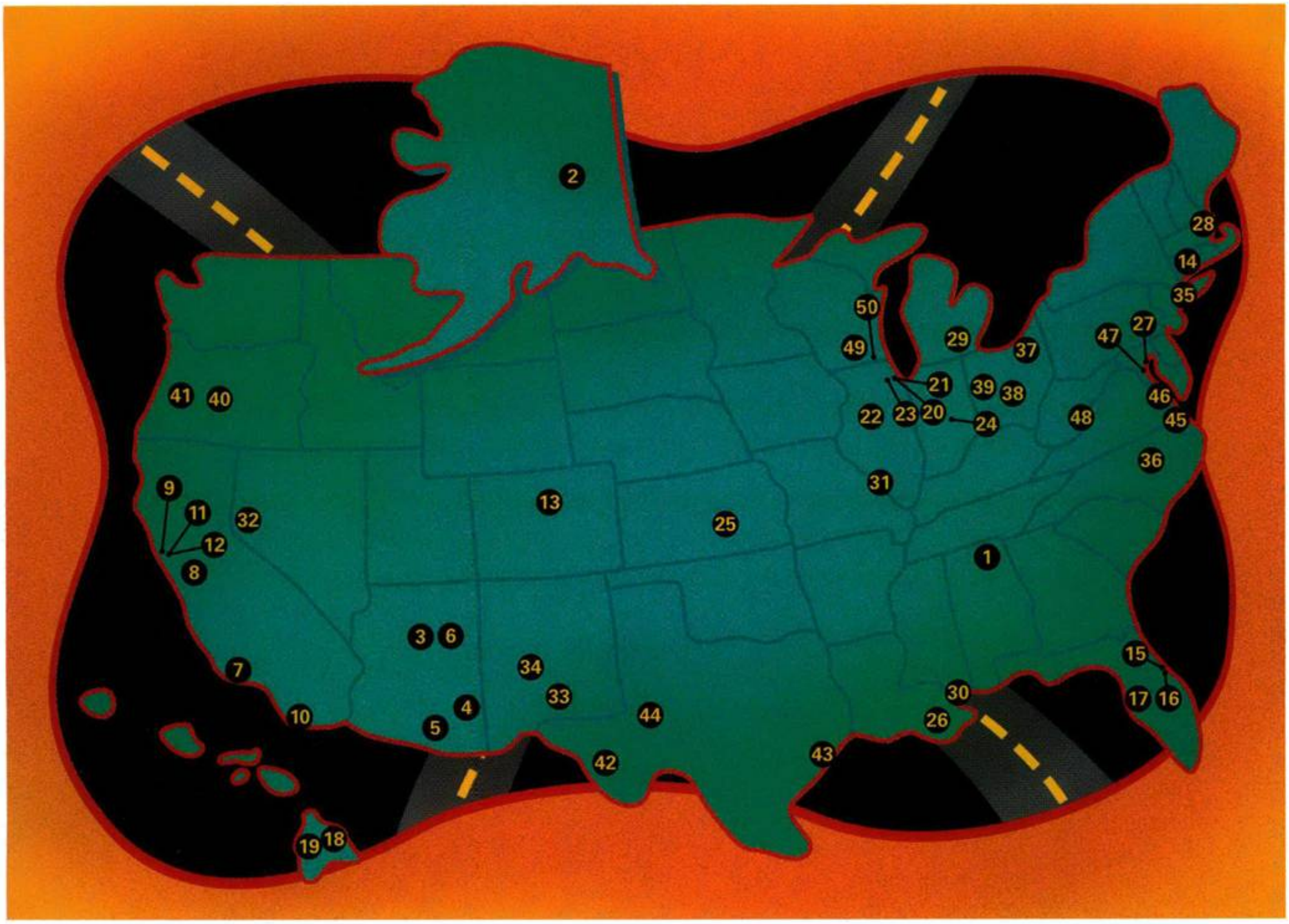
The sixth largest meteor crater in the world has been largely filled with sediment, but you can still see what remains and take a tour for free. See the limestone that was pushed to the surface during impact, but don't expect it to be anything like Barringer Meteor Crater, or you're sure to be disappointed. Open every day.

VIRGINIA

㊺ Hampton

Virginia Air and Space Center
600 Settlers Landing Rd.
Zip: 23669
Phone: 1–800–296–0800
Website: http://www.vasc.org

At the official Visitor Center for the NASA Langley Research Center are 100 exhibits, most notably the Apollo 12 Command Module, a moon rock, a Mars meteorite, and rocket and shuttle simulators.



IMAX films are shown daily.

㊻ Wallops Island

Wallops Flight Facility Visitor Center
Bldg. J–17, Rt. 175
Zip: 23337
Phone: (757) 824–2298
Website: http://www.wff.nasa.gov/~WVC (Virtual Tour Available)

Explore the past, present, and future of space flight through the center's exhibits. Films run throughout the day, and group tours are available for your astronomy club or family reunion. Check their schedule for special programs.

WASHINGTON, D.C.

㊼ Washington, D.C.

National Air and Space Museum
National Mall
7th and Independence Avenue, S.W.
Zip: 20560
Phone: (202) 357–2700
Website: http://www.nasm.edu

The planetarium and IMAX films are incidental compared to the vast array of artifacts on display. Among the galleries are Apollo to the Moon, Looking at Earth, Exploring the Planets, Stars, Lunar Exploration Vehicles, Rocketry and Space Flight, and Space Hall. More than one day exploring here would be ideal. Renovations during 2001, including the opening of Explore the Universe, have made it even better.

WEST VIRGINIA

㊽ Green Bank

National Radio Astronomy Observatory
Route 28
Zip: 24944
Phone: (304) 456–2011
Website: http://info.gb.nrao.edu

A new learning center will soon provide programs and interactive exhibits. Tour the facility for free during the summer and on fall weekends and see a scale-model solar system on the grounds. Among the scheduled special events are star parties, high-tech tours, and opportunities to use computers to do astronomy.

WISCONSIN

㊾ Madison

UW Space Place
1605 S. Park Street
Zip: 53715
Phone: (608) 262–4779
Website: http://www.sal.wisc.edu

The Space Astronomy Laboratory of the University of Wisconsin, Madison, began an outreach program over a decade ago to educate the public. Check its schedule for lectures by the University's faculty. Family workshops are available for parents with children ages 6 to 10. Its best idea yet has been Universe in the Park, during which, on summer weekends, a star party is arranged at one of Wisconsin's state parks, featuring an introductory talk about astronomy followed by viewing through telescopes.

㊿ Williams Bay

Yerkes Observatory
373 W. Geneva St.
Zip: 53191
Phone: (262) 245–5555
Website: http://astro.uchicago.edu/yerkes (Virtual Tour Available)

This old institution, which has hosted the likes of Albert Einstein, Subrahmanyan Chandrasekhar, and a young Carl Sagan, offers tours on Saturdays. See the world's largest refractor and the massive elevator used for viewing. The Quester Museum is housed inside the building, along with a small gift shop.

sky Show

march

Spring warms up with spicy solar system action.

by Martin Ratcliffe and Alister Ling

The moon, Venus, Jupiter and Mars shine in conjunction above the high Sierras. John Thielen

The brilliant stars of winter shine prominently across the southern half of the sky. Together they trace out a huge capital letter G, but the addition of Jupiter makes it look more like a curly number 6. Though the giant planet appears as one of the brightest objects in the sky, it is far from being one of the biggest. In fact, if the star Betelgeuse were placed at the center of the solar system, this red giant would bulge out and engulf Jupiter.

After a long winter's absence, the lovely Venus finally reclaims its title as the "evening star." At the start of the month it lies hidden in the golden glow of the western sky but slowly climbs up toward Mars. Then, as if by marching order the planets form an almost straight line from Venus, Mars, Saturn, and all the way up through Jupiter. This plane of the solar system's planets that we see edge-on is the ecliptic.

Eclipse is at the root of the word ecliptic, for it is along this line that eclipses in the solar system occur. Two special eclipses happen this month; unfortunately neither is visible from most of North America. On March 20, the moon occults Saturn if you are stationed somewhere from northeastern Africa to northern Japan and Russia. The moon occults Jupiter on March 22 for those in the arctic regions.

Globular cluster M79 sparkles like a gem in the constellation Lepus. Preston Scott Justis

Asteroids are the most common objects to roam the ecliptic. This month, Vesta cruises through Taurus, skimming so close to Saturn on March 18 and 19 that it might be mistaken for one of the planet's moons. You can follow Vesta's voyage with a small telescope even from an urban backyard.

Comet watchers are keeping close tabs on LINEAR WM1, hoping it might flare in brightness. Because it is best seen from a dark sky in the early morning, you may want to hold out until the weekend of the new moon to try and glimpse it through your telescope.

The weekend of the new moon also hosts the great dusk to dawn "Messier marathon," a challenge for observers worldwide to see how many of the sky's 110 best galaxies, star clusters, and gas clouds they can find in one night. The French comet hunter Charles Messier began to compile his now-famous list in the latter part of the 18th century.

Even under the glow of city lights plenty of interesting sights await you this month. Below the sparkling stars of Orion lies the constellation Lepus the Hare. Here you can find a globular cluster, double and multiple stars, and a drop of stellar blood: "Hind's Crimson Star."

2002 March

1 Jupiter is stationary, 10 A.M. EST

5 Last quarter moon is at 8:24 P.M. EST

8 Mercury passes 1.2° south of Uranus, 10 P.M. EST

10 The moon passes 4° south of Neptune, 4 A.M. EST
Asteroid Euterpe is at opposition, midnight EST

11 The moon passes 4° south of Uranus, noon EST
The moon passes 3° south of Mercury, 8 P.M. EST

13 The moon is at apogee (252,716 miles from Earth), 8:09 P.M. EST
New moon is at 9:02 P.M. EST

17 The moon passes 4° south of Mars, 8 P.M. EST

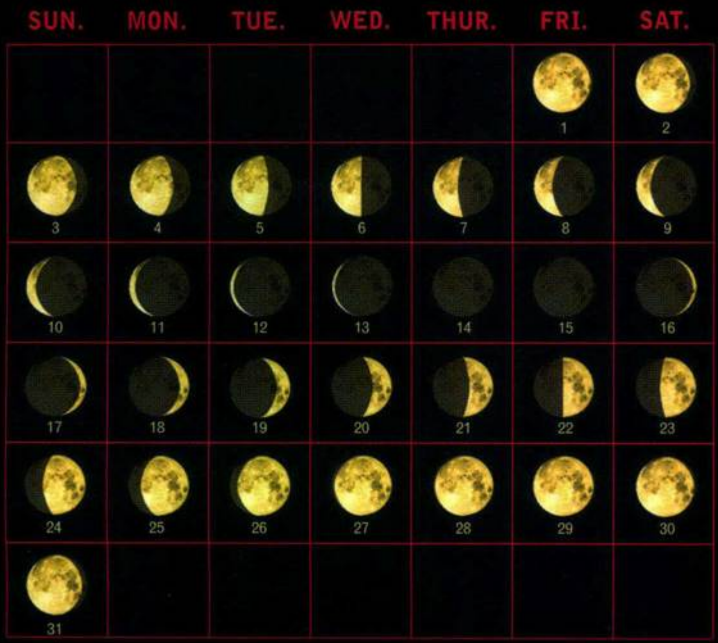
20 The moon passes 0.5° north of Saturn, 5 A.M. EST (page 59)
The moon passes 0.5° north of Vesta, 5 A.M. EST
Vernal equinox is at 2:16 P.M. EST

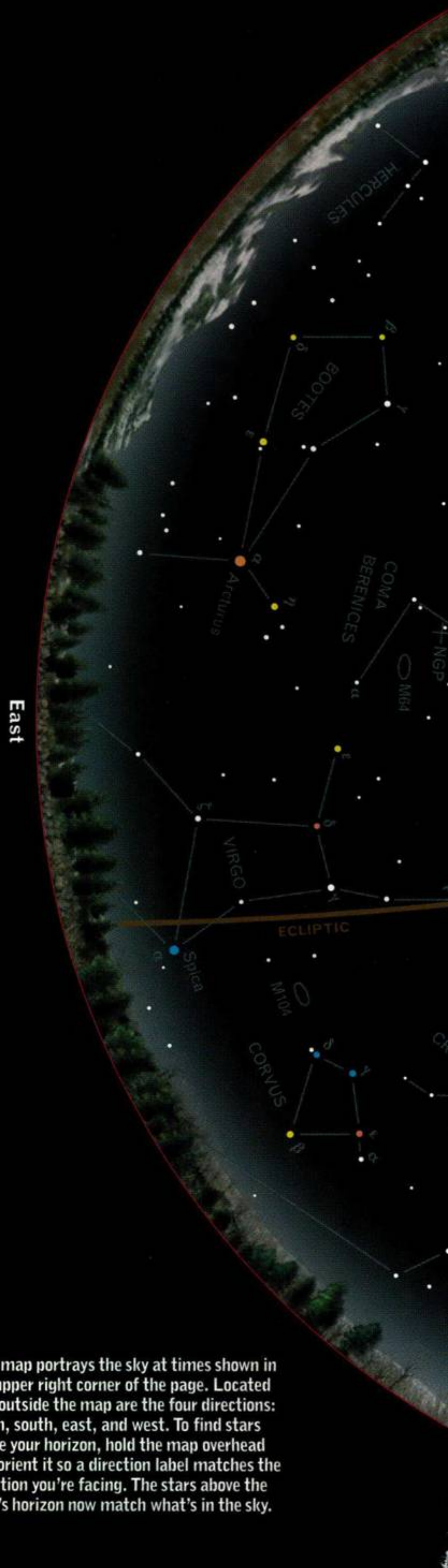
21 First quarter moon is at 9:28 P.M. EST

22 The moon passes 1.1° north of Jupiter, 7 A.M. EST (page 59)

28 The moon is at perigee (221,836 miles from Earth), 2:41 A.M. EST
Full moon is at 1:25 P.M. EST

31 Saturn passes 4° north of Aldebaran, 11 A.M. EST

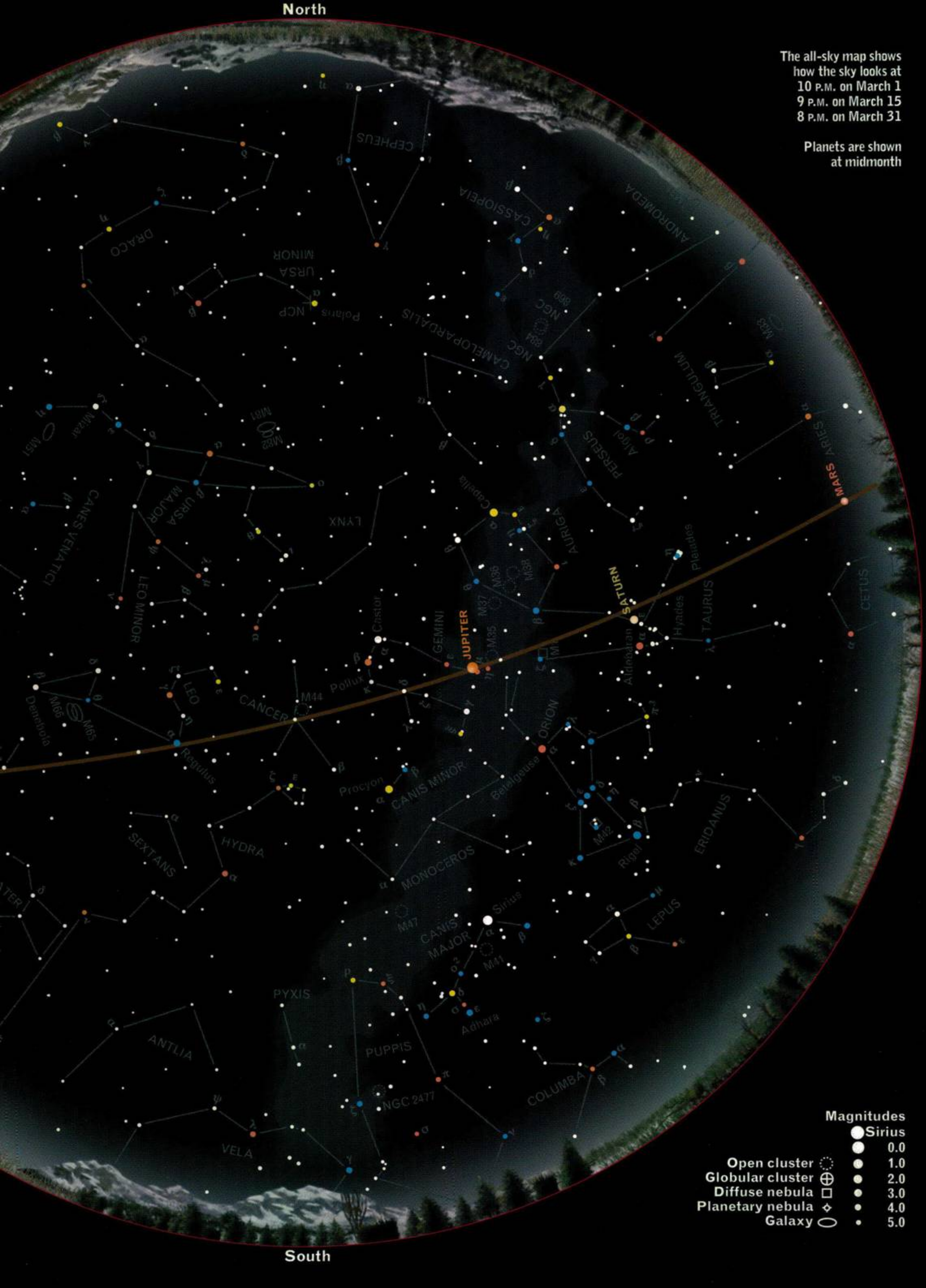




This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

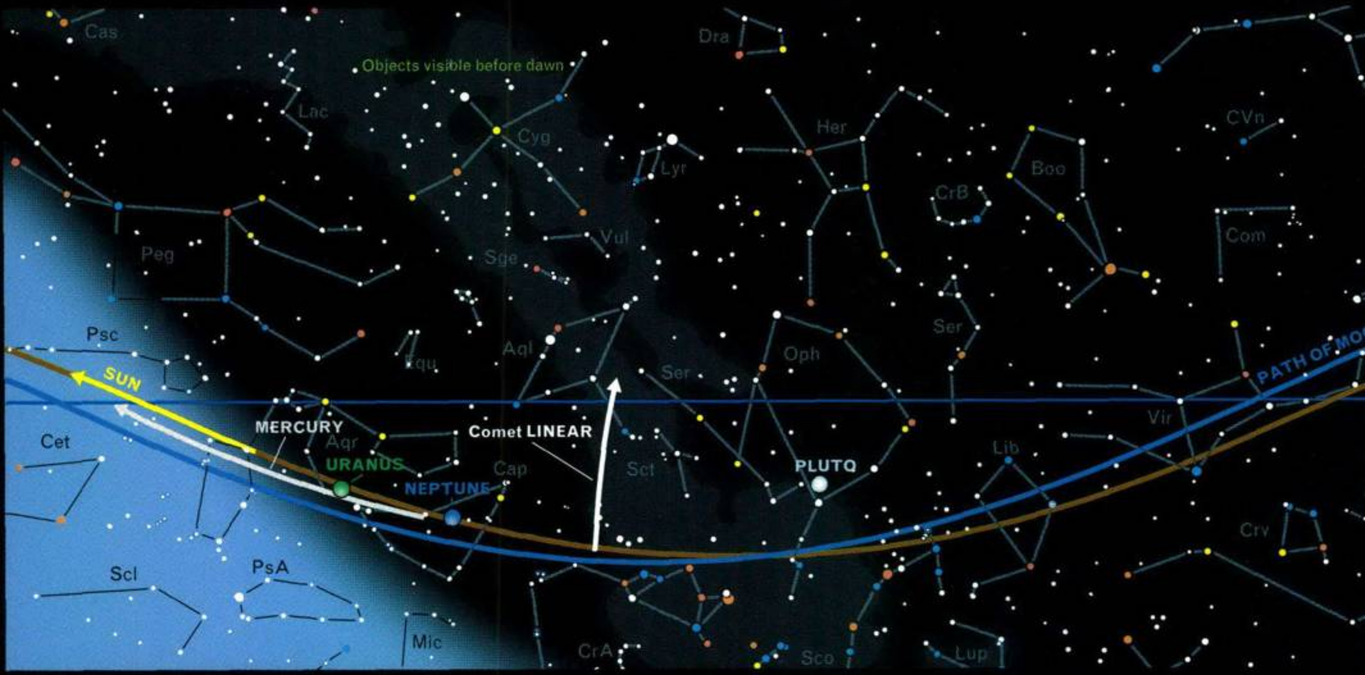
The all-sky map shows how the sky looks at
10 P.M. on March 1
9 P.M. on March 15
8 P.M. on March 31

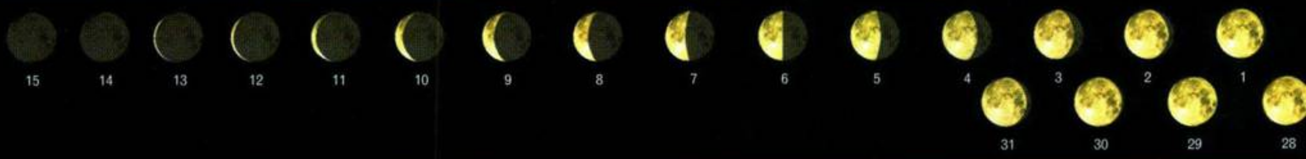
Planets are shown at midmonth


North
South
West
CEPHEUS
CASSIOPEIA
ANDROMEDA
DRACO
URSA MINOR
Polaris
NCP
CAMELOPARDALIS
NGC 869
NGC 884
M33
TRIANGULUM
PERSEUS
Algol
ARIES
MARS
M51
Mizar
M81
M82
URSA MAJOR
CANES VENATICI
LYNX
Capella
AURIGA
Pleiades
M36
M38
M37
SATURN
LEO MINOR
GEMINI
JUPITER
Castor
M35
M1
Hyades
TAURUS
Aldebaran
CETUS
Pollux
CANCER
M44
LEO
Denebola
M66
M65
Regulus
ORION
Betelgeuse
Procyon
CANIS MINOR
M42
Rigel
ERIDANUS
SEXTANS
HYDRA
MONOCEROS
LEPUS
CRATER
M47
CANIS MAJOR
Sirius
M41
PYXIS
Adhara
ANTLIA
PUPPIS
COLUMBA
NGC 2477
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system object


Cas
Objects visible before dawn
Dra
Lac
Cyg
Lyr
Her
CVn
Boo
CrB
Com
Peg
Vul
Sge
Psc
Equ
Aql
Ser
Oph
PATH OF MO
SUN
Cet
MERCURY
Aqr
Comet LINEAR
Vir
URANUS
NEPTUNE
Cap
Sct
PLUTO
Lib
Crv
Scl
PsA
Mic
CrA
Sco
Lup


15
14
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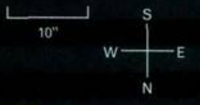
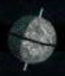
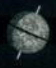
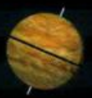
4
3
2
1
31
30
29
28

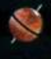
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPI
Date	March 1	March 15	March 15	March 15	Marc
Magnitude	0.0	−0.3	−3.9	1.4	−2
Angular Size	6.3"	5.4"	10.2"	4.6"	40.
Illumination	70%	84%	97%	94%	99
Distance (AU) from Earth	1.076	1.240	1.644	2.039	4.9
Distance (AU) from Sun	0.465	0.451	0.724	1.513	5.1
Right Ascension (2000.0)	21h09.6m	22h29.3m	0h33.3m	2h27.5m	6h25
Declination (2000.0)	−17°24'	−11°50'	2°23'	15°01'	23°





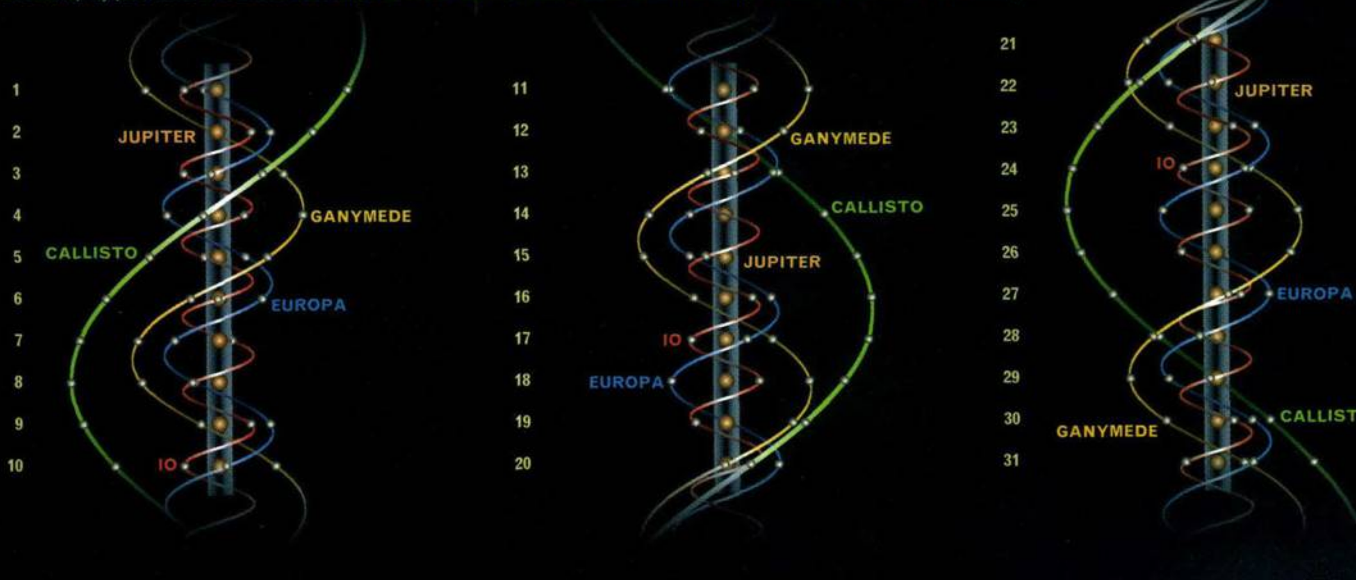




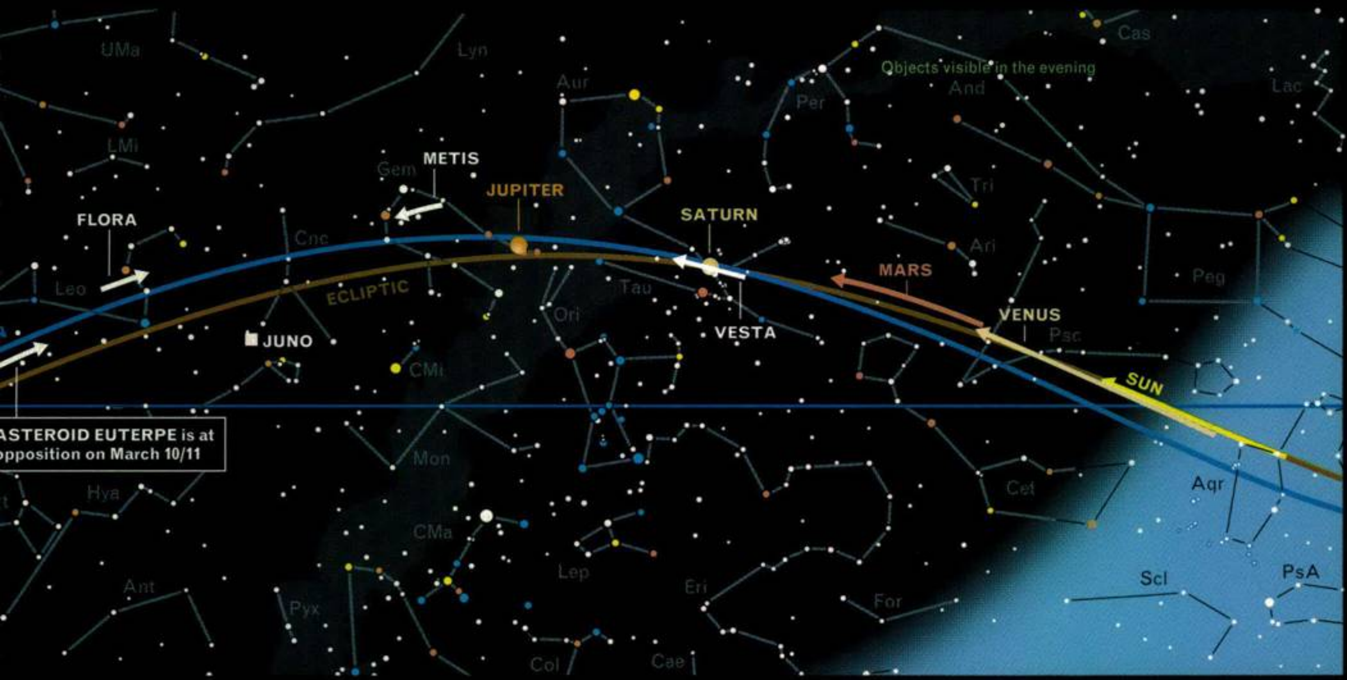


Jupiter's Moons

Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope.



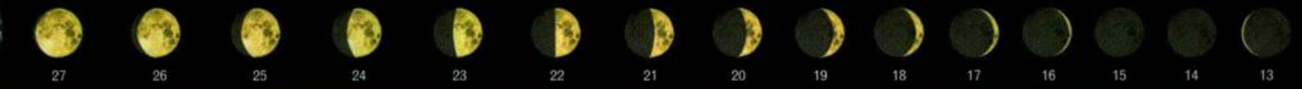
during the month.


UMa
Lyn
Cas
Aur
Per
And
Lac
LMi
METIS
Gem
JUPITER
Tri
FLORA
Cnc
SATURN
Ari
Leo
ECLIPTIC
Tau
MARS
Peg
Ori
VENUS
Psc
VESTA
JUNO
CMi
SUN
Mon
Aqr
Hya
Cet
CMa
Lep
Ant
Eri
Scl
PsA
Pyx
For
Col
Cae

Objects visible in the evening

ASTEROID EUTERPE is at opposition on March 10/11

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.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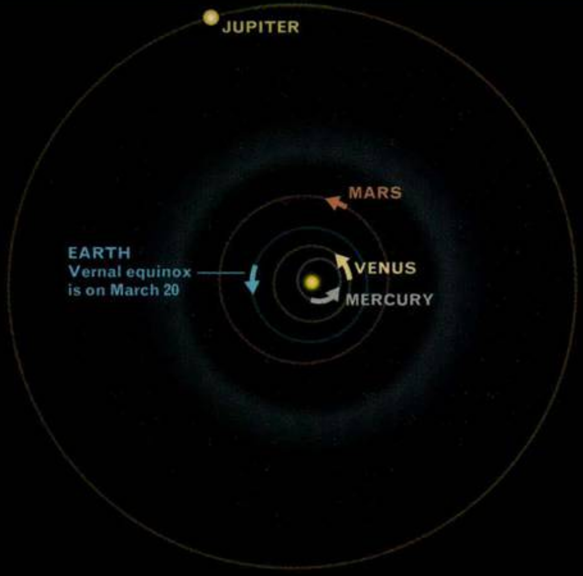
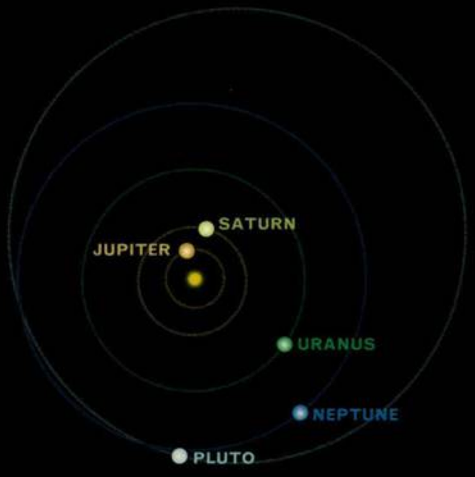
SATURN	URANUS	NEPTUNE	PLUTO
March 15	March 15	March 15	March 15
0.1	5.9	8.0	13.8
17.9"	3.4"	2.2"	0.1"
100%	100%	100%	100%
9.263	20.868	30.799	30.358
9.055	19.994	30.093	30.487
4h30.7m	21h55.7m	20h49.8m	17h09.8m
20°20'	–13°22'	–17°39'	–12°55'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
MARS
EARTH
Vernal equinox
is on March 20
VENUS
MERCURY


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

Star-hopping in Lepus the Hare

The prominent and mighty hunter Orion practically squashes little Lepus out of view. The constellation of the hare would be much more obvious if it were located in the relatively barren skies of autumn. Lepus consists of two sparkling chains of stars, with its two brightest stars rivaling all those in Gemini, except for Castor and Pollux.

Lepus is perhaps best known for housing winter's lonely globular star cluster M79. The cluster's 8th-magnitude glow spans a modest 10', one-third the apparent diameter of the moon. As a result, M79 appears faint from an urban location.

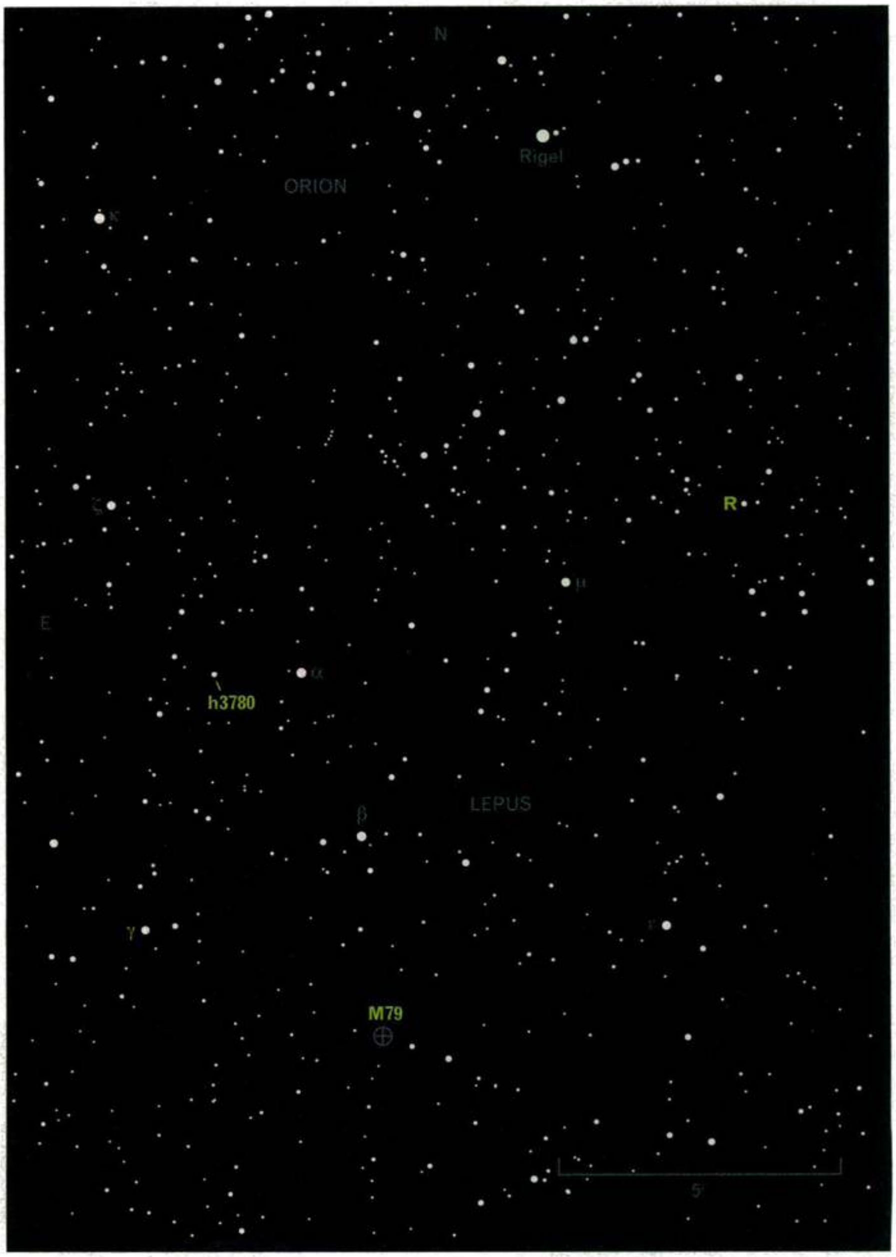
Messier's colleague Pierre Méchain discovered M79 on December 17, 1780. To see its supergiant stars sparkle you'll need steady skies and at least a 6-inch telescope at high power. The bright members pop in and out of view against the rather diffuse glimmer of the star cluster.

An easy target from the city is the multiple star h3780, which was first discovered by the prolific observer John Herschel. It consists of six stars, four of which are rather bright. In fact, it is also listed in the *New General Catalogue* as a star cluster and bears the designation NGC 2017. Observer George de Lange says it reminds him of "a naked-eye view of the Pleiades, except that the stars have color." This bright, small clump lies only 2° from Alpha (α) Leporis. A simple way to get there is to point your telescope at Alpha and wait for Earth's rotation to bring it into view 6 ½ minutes later.

Brighter still and maintaining some color is the double-star system of Gamma (γ) Leporis. The wide pair is seemingly yellow and orange, but every observer has his or her own unique color perception. What shades do you behold through your scope?

In searching for other colorful stars, you may want to capture Hind's Crimson Star, which is located near Mu (μ) Leporis, the bright star at the upper right of Lepus's form. This glowing red ember is also known as R Leporis, a long period variable. Its color ranges from orange, when it's near maximum, to a "pinprick of blood" at its faintest. As luck would have it, it should be quite red for the next couple months. Ideally, telescopes of 8 inches or more are best at bringing its color home, but a 4-inch telescope should reveal some hue at medium power.

In general, to capture celestial colors at their best, it's important to look at an object directly so that light falls on the eye's central region, where there is the highest concentration of color receptors, or cones. Averted vision — the technique of glancing to the side of the field of view — is great for glimpsing faint objects, but it sacrifices color sensitivity. Another technique for seeing color optimally is to stare as long as possible at the object. This makes color "build up" on your retina and often causes an object to appear brighter — a phenomenon first reported by the Czech physiologist Johannes Purkinje and since dubbed the "Purkinje effect."



Saturn Visits the Clusters of Taurus

While Mars continues to skip across Aries, Jupiter and Saturn dominate the evening sky after sunset. Jupiter will be the first shining "star" you'll see in the darkening southern sky. Follow a line from Jupiter down toward the western sunset and you'll be tracing the ecliptic. Along this line you'll find Saturn within the constellation Taurus the Bull, followed by Mars, which will appear a whole magnitude fainter than Saturn.

Mars shines at magnitude 1.3, a bright object in an otherwise empty region of the sky. The waxing crescent moon lies 4°, or one binocular field, south of Mars on March 17. Nothing can be seen on Mars through a telescope — its tiny disk is too distant to reveal any details. Mars will continue to linger in the western portion of the sky for a few months.

The Red Planet chases Earth around the sun stubbornly, and at a lower speed because it orbits farther from the sun than we do. Kepler's Third Law of Planetary Motion, sometimes called the "Harmonic Law," explains why "superior" planets move around the sun more slowly than "inferior" ones. The Harmonic Law also provided early astronomers with a tool to calculate the relative distances of the planets from the sun. We know today that Mars lies approximately 1.4 to 1.7 AU from the sun over the course of its orbit (1 AU = 93 million miles).

Venus makes a brief appearance in the evening sky shortly after sunset. Follow the ecliptic from the brighter planets, through Mars and down toward the western horizon. Within one hour of sunset, Venus should be visible above a clear western horizon, shining at magnitude –3.8. Even a small telescope will reveal a tiny and almost fully illuminated disk.

Saturn glows at magnitude 0.1 and dominates the constellation Taurus the Bull. Its yellowish glow contrasts nicely with the orange-hued Aldebaran, the brightest star in Taurus. Aldebaran marks one end of the V-shaped cluster of stars called the Hyades. For a while Saturn appears to stand close to the northerly tip of the "V." Through progressive nights you can watch Saturn move slowly eastward relative to these stars. This movement reflects Saturn's true motion around the sun combined with Earth's motion. Each night our rapid daily rotation carries the stars and Saturn from east to west. By the end of March Saturn lies 4° north of the conspicuous giant Aldebaran.

The excitement of seeing Saturn through a telescope for the first time hooks many people on observing. In 1610, Galileo first saw Saturn's rings with his telescope. Watchful observers may even see gaps in the planet's rings. Spot Saturn on March 19 when it hangs between the Pleiades and Hyades and lies 4° east of the moon.

Saturn slowly changes its aspect due to the 26° axial tilt of its orbit. Currently we see the southern side of the planet's rings, but this is not always the case. By late 2009 the rings will appear edge-on, and during the years following we will view the northern plane of the rings. Saturn takes a little less than 30 years to round the sun, so it takes that same time to see the full cycle of Saturn's changing appearance.

Easiest of all the saturnian moons to view is Titan. It glows at magnitude 8.3 and is visible in small scopes. In the first two days of March Titan lies west of Saturn, then swings south of the planet by March 6 and east on March 10. Passing north of Saturn on March 14, Titan returns to its westerly position on March 17 and repeats the cycle once more during the month.

Larger telescopes should capture Iapetus, the saturnian moon with variable brightness due to the light and dark patches on its surface. During late

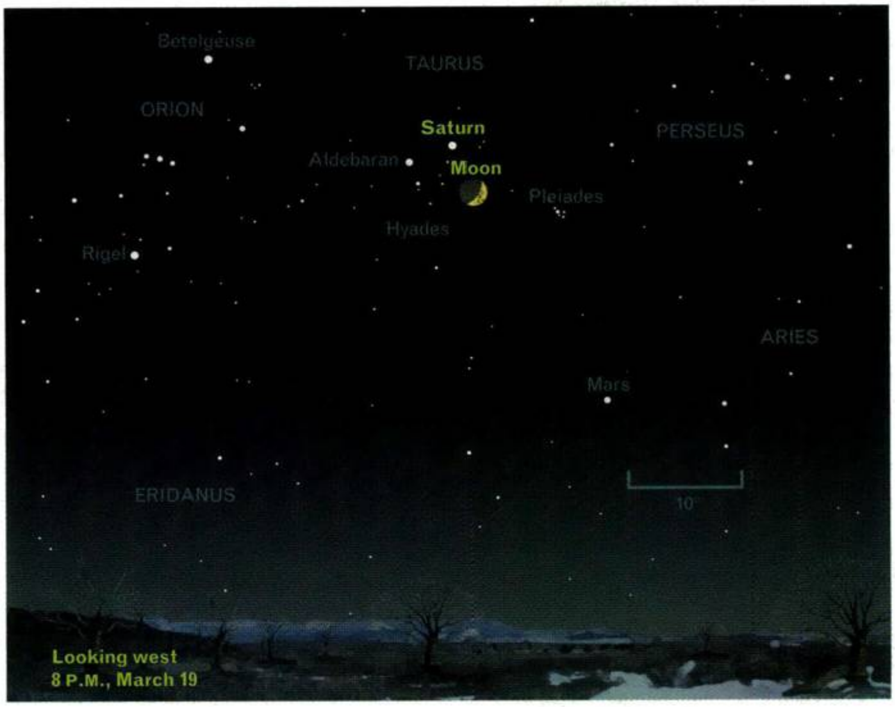
The "seven sisters" glow in the midst of an eerie blue Merope Nebula. Dennis Staffne

March, Iapetus is approaching a western elongation — the point when it appears brightest at magnitude 10.2. Western elongation occurs on April 1, and following that date the moon will begin to fade again as its darker side turns to face us. The next time Iapetus shines so brightly will be in the early morning skies of September, so take advantage of the present opportunity.

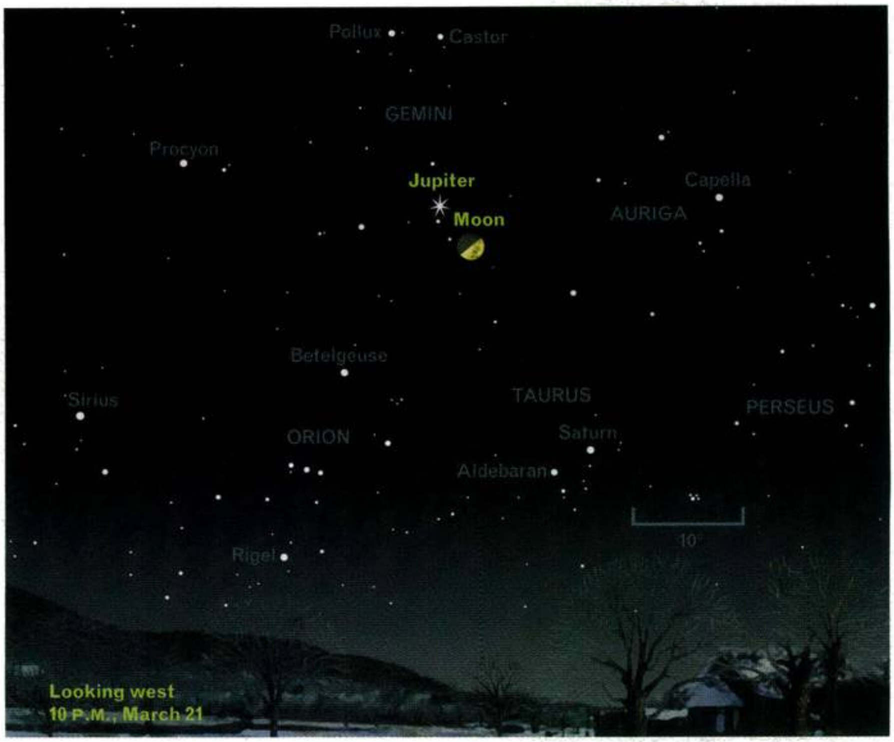
The quintessential cold-weather cluster — the Pleiades — also lies within Taurus's borders. So catch it before it sets for the summer. This cluster presents six stars to the naked eye that form the shape of a tiny dipper. In Greek mythology the Pleiades were the seven daughters of Atlas, so the cluster is sometimes referred to as the Seven Sisters. Since the cluster was first named, though, one of the "sisters" has faded from naked-eye visibility. Some telescopes can pick up a second feature of this cluster — the Merope Nebula. Starlight reflects off surrounding gas and dust here, producing the nebula's breathtaking bluish-white wisps.

Jupiter begins March in Gemini lying 1° north of the magnitude 2.8 star Mu (μ) Geminorum. Jupiter is very bright, shining at magnitude –2.4 at the beginning of the month. By the end of the month the planet fades two-tenths of a magnitude. On March 21 you'll find the gaseous giant Jupiter lying 5° east of the moon.

Cloud details on Jupiter will stand out in any telescope. Quick glances through even a modest scope should show the planet's dark equatorial bands. More deliberate and patient viewing should reveal subtle features in the rest of Jupiter's dynamic atmosphere, which cross the face of the planet in just a few hours. Four bright moons protrude from the surrounding darkness. Take a look — sometimes it's hard to see all four moons because one or two are often hidden behind Jupiter or transiting the planet. Observing events involving the Galilean satellite Callisto are rare and are listed in this month's "Meteors and Moons" section. Both disappearance and reappearance of Callisto take place east of Jupiter's disk — another unusual event.



Looking west
8 P.M., March 19



Looking west
10 P.M., March 21

Mercury appears in the morning sky. It lies too far south for observers in the Northern Hemisphere to see but is well placed for those viewing from the Southern Hemisphere.

Earth reaches the spring, or vernal, equinox on March 20 at 19:16 Universal Time (GMT), or 2:16 P.M. EST. "Equinox" stems from the Latin *equinoxe* meaning "equal night."

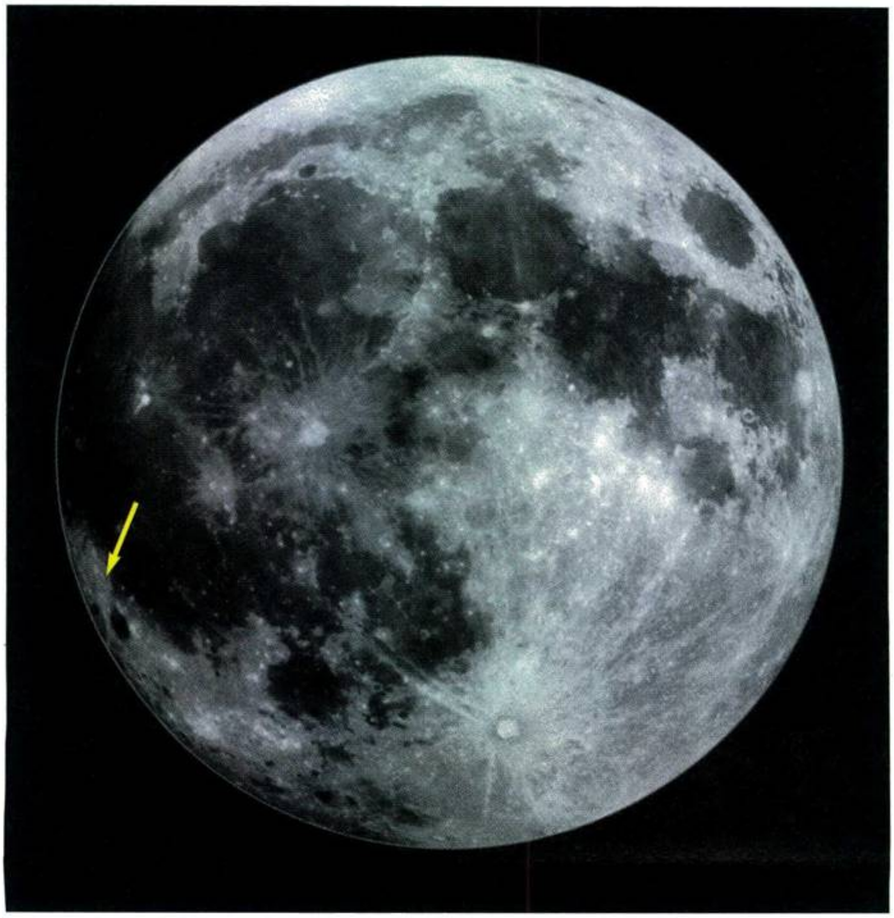
Meteors and Moons

The Lunar Feature of Hevelius

On the western limb of the moon, north of the dark flooded plain of Grimaldi and bordering Oceanus Procellarum, is the giant 75-mile-wide crater Hevelius. This crater is named for the German astronomer Johannes Hevelius, who made the first detailed lunar map and named many of the moon's landscape features, although few of his designations survive today.

A central mountain punctuates Hevelius's floor, which is crisscrossed by rilles that are evident in just the right sunlight. To the north of the main crater, almost attached to the wall, is the small crater Cavalerius. This 40-mile-wide feature has broken the more ancient wall of Hevelius, which means Cavalerius represents a younger impact. On the southern wall of Hevelius sits the smaller crater Lohrman. Other smaller impacts dot the western walls of Hevelius. You can catch the early morning sunlight on this system of craters a day or so before full moon, which falls on March 28.

Below: Jupiter is never alone with its illustrious Galilean satellites. Ronald Boyer
Bottom: Lunar crater Hevelius (arrow) as imaged from rural Wisconsin. Kevin Bert



Jupiter's Satellites

The rare events involving occultations, transits and eclipses of Jupiter's fourth Galilean moon, Callisto, continue this month. During each 12-year orbit of Jupiter around the sun, only two series of eclipses involving Callisto occur. Below is a table of events, given in Universal Time (Greenwich Mean Time) and Eastern Standard Time (EST). Events that occur on either side of midnight are shown twice (*), since the date changes for observers in Europe or the United States of America. Tr = Transit; I = Ingress; E = Egress; Oc = Occultation; Sh = Shadow Transit; Ec = Eclipse; D = Disappearance; R= Reappearance. The IV denotes Callisto (as the fourth Galilean moon). All of these events are worth viewing due to their relative rarity. Be forewarned that not all are visible from the United States.

Callisto Events for March 2002

	UT	EST	
Mar. 4	23:57	6:57 P.M.	IV.Tr.I.
		9:45 P.M.	IV.Tr.E.*
Mar. 5	2:45		IV.Tr.E.*
	11:03	6:03 A.M.	IV.Sh.I.
	14:24	9:24 A.M.	IV.Sh.E.
Mar. 13	6:35	1:35A.M.	IV.Oc.D.
	9:29	4:29A.M.	IV.Oc.R.
	18:20	1:20 P.M.	IV.Ec.D.
	21:48	4:48 P.M.	IV.Ec.R.
Mar. 21	17:11	12:11 P.M.	IV.Tr.I.
	20:06	3:06 P.M.	IV.Tr.E.
Mar. 22	5:06	0:06 A.M.	IV.Sh.I.
	8:35	3:35 A.M.	IV.Sh.E.
Mar. 29		7:16 P.M.	IV.Oc.D.*
		10:19 P.M	IV.Oc.R.*
Mar. 30	0:16		IV.Oc.D.*
	3:19		IV.Oc.R.*
	12:23	7:23 A.M.	IV.Ec.D.
	16:00	*11:00 A.M.*	*IV.Ec.R.*

Comet LINEAR WM1 Continues

A dusty, dirty, icy glob of material that failed to incorporate into larger solar system bodies provides for nice viewing. Comet LINEAR WM1 has faded since its peak in December, but it should still glimmer between 7th and 8th magnitudes. The best chance to see it will be when it rises in the predawn sky. The weekend of March 16 will be best for glimpsing LINEAR WM1, when the intrusive glow of the moon stays below the horizon.

Use the chart to hop from M11 — the Wild Duck Cluster in Scutum — to its lower left into southern Aquila. Start at low power to see how long the tail is. One trick for seeing faint tails is to move the scope past the visible end, then rock the view back and forth across where the extension should be. Peripheral vision detects contrast well.

Next, jump up to mid power, familiarize yourself with the field, then push the power up to 30x per inch or more (atmosphere allowing) — for example, 240x for an 8-inch aperture.

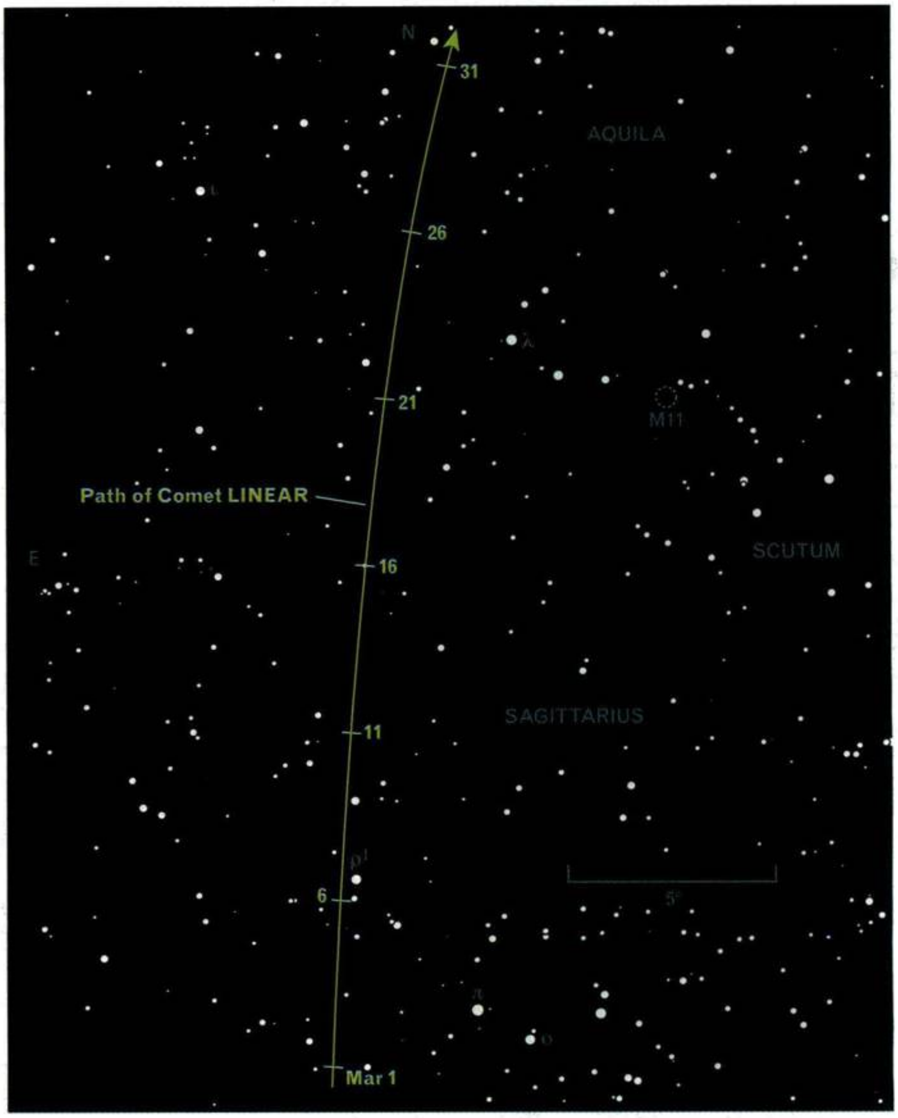
Saturn's Temporary "Moon" — Vesta

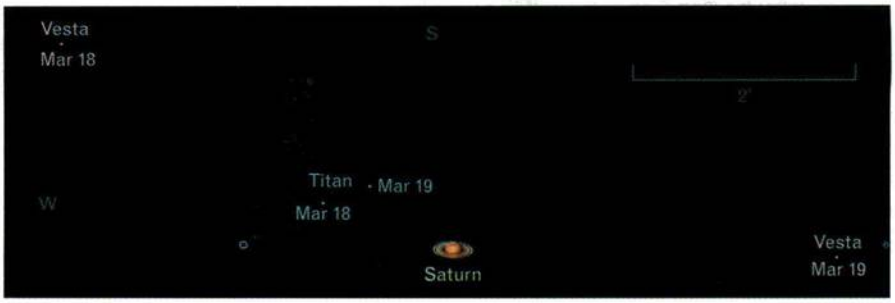
Every now and then, a background star masquerades as an extra moon of Jupiter or Saturn for a night. But on this relatively rare occasion, it's a foreground asteroid that disguises itself as a saturnian satellite.

Of the many widely scattered rocky masses that orbit between Mars and Jupiter, Vesta was the fourth discovered. Yet it is the third largest asteroid at 300 miles (500 km) across. Glowing at 8th magnitude, Vesta compares in brightness to Saturn's large moon Titan. From the backyard, you should be able to follow Vesta quite easily in the smallest of scopes, or even with a steadily held pair of binoculars.

On the nights of March 18 and 19, the asteroid will be the brightest point of light close to Saturn, with the exception of Titan itself. Vesta will appear quite close to Saturn, about the distance of the apparent size of our moon, or 30'. From Earth's Eastern Hemisphere observers will see it pass a mere 2' to the south of Saturn. Astrophotographers may want to grab their cameras and capture an asteroid and planet in one frame.

In case those nights are cloudy, you may still be able to catch the asteroid Vesta on the nights of March 23, 25, and 31, when it glides by some more conspicuous background stars. ◼





Martin Ratcliffe is president of the International Planetarium Society. Alister Ling is a meteorologist for Environment Canada.

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Authorized Meade Dealer

Meade ETX-90EC **$495**

Meade ETX-105EC **$695**

Meade ETX-125EC **$895**

#497 Autostar **$99**

Hardly a day goes by that we don't get a note or E-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. Dealer so and so advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!"

If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $99 to $27,995.

And we can usually ship your right telescope right away, since we have over 1000 telescopes in stock!

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We have the Meade LX90 in stock (41 on 12/10).

Meade 8" LX90 **$1695**

You can live the good life of big-aperture go-to full-featured fully computerized astronomy for not very much money with the 8" **Meade LX90** Schmidt-Cassegrain.

The LX90 is only $1695, including an adjustable height field tripod and a go-to Autostar computer with 30,223 stars and objects in its data base. Battery-operated, with a big 8 x 50mm finder and a 26mm Super Plössl eyepiece, it's ready to observe as soon as you receive it.

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Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

The new Meade GPS scopes. You do the looking. They do the work.

Meade 8" LX200 GPS **$2495**

Never before have so many features been packed into one telescope series. And never before have big aperture go-to scopes been so easy to use. The new LX200 GPS scopes – the widest variety of go-to telescope sizes and focal ratios on Earth – have the features you've dreamed about since you started astronomy.

Fully automatic GPS alignment, with true north and true level sensors and automatic magnetic declination correction; a unique mirror lock to eliminate image shift during critical CCD imaging sessions; a standard equipment 4-speed electric focuser; a built-in computer database of over 125,000 stars and objects; flashlight battery operation; and much more.

The Meade GPS scopes are designed to let you spend more time looking *at* celestial objects and less time looking *for* them. And isn't that what you want out of a telescope? Chances are good we have your personal Meade GPS scope in stock.

Losmandy mounts are in stock.

Losmandy G-11

If you're looking for a premium quality German equatorial mount, look no further than the Losmandy GM-8 and G-11 mounts we stock. They have adjustable height tripods and dual axis drives with PEC drive correctors. There are optional adapters available to fit virtually any catadioptric or refractor optical tube, plus Losmandy accessories to customize the mount to your heart's content. We even stock go-to mounts and Gemini go-to retrofit kits.

Meade LXD55 scopes make other reflectors and refractors obsolete.

Meade 5" LXD55 **$695**

For little more than the cost of an ordinary equatorial refractor or reflector, you can get a fully computerized Meade LXD55. The go-to capability of the LXD55 series is the most significant advance in an affordable German equatorial mount since its invention in the early 1800s!

You won't spend your time hunting for faint deep space objects with a 5" or 6" LXD55 refractor or a Schmidt-Newtonian 6" to 10" reflector. A few touches on the keypad of the built-in Autostar computer sends your scope speeding to any of the more than 30,000 stars and objects in its memory, centers it on the object, and tracks it while you observe. For many people, star hopping will become obsolete. You'll spend more time looking *at* deep space objects and planets and less time looking *for* them with an LXD55.

Full details are on our website and in Meade's ads in this magazine. Scopes will start shipping about the time this magazine hits your mailbox. Order now to be one of the first to get your scope out of the dark ages.

$729 Meade 8" LXD55

Fuji astro binoculars!

Comet Hyakutake, among others, was discovered with 150mm Fujinon binoculars. There's no guarantee that *you* will discover a new comet with a 10 x 70mm or 16 x 70mm Fujinon FMT-SX binocular, but we can guarantee that the 70mm Fujinons are built to the same premium optical quality standards as the big Fujis. For pricing and full details, see our newly redesigned and expanded website at **www.astronomics.com**.

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TMB 100

More and more TMB refractors are in the hands of some very delighted customers of ours, and the buzz about them grows and grows. Visit our website to see the scopes that are the talk of experienced astronomers everywhere.

TMB 80/6	80mm (3.1") f/6	**$1390^{00}**
TMB 80/7	80mm (3.1") f/7	**1390^{00}**
TMB 100	100mm (4") f/8	**3290^{00}**
TMB 105	105mm (4.1") f/6.2	**3290^{00}**
TMB 152	152mm (6") f/7.9	**6990^{00}**
TMB 175	175mm (7") f/8	**11,990^{00}**
TMB 203	203mm (8") f/9	**19,990^{00}**
TMB 254	254mm (10") f/9	**39,995^{00}**

A $450 binocular for only $179^{95}!

We bought 400 Celestron/Tasco 8 x 42mm roof prism binoculars at a great price that lets us sell them for *$70 below regular dealer cost.*

Armored, waterproof, multicoated, BaK4 prisms, soft case, wide neck strap, 6.6° field, 16mm eye relief, and a ***No-Fault*** lifetime Tasco warranty! If they ever break, send them to Tasco with $10 for handling and they'll be repaired or replaced for free!

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We stock Pentax XL eyepieces from 227^{\underline{50}}$.

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We stock Lumicon light pollution filters . . . the deep sky standard.

If city lights are blocking your view of the heavens, get rid of the light pollution with one of the many Lumicon nebula filters we stock. All are available in 1.25", 2", and rear cell versions for SCT use. We also have two-filter sets in various combinations at money-saving package prices.

Deep Sky: broadband filters for visually and photographically observing nebulas from moderately light-polluted areas.

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Oxygen III: visual line band for emission nebulas from badly light-polluted areas.

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TeleVue scopes are in stock (as is everything else by TeleVue).

NP-101 $3385

TV-85 $2080

We have all the TeleVue scopes in stock, and in depth. Just look at this selection . . .

NP-101, standard package	$\$3385^{00}$
Renaissance-102, standard package	2935^{00}
TV-102, standard package	2635^{00}
TV-102, optical tube only	2200^{00}
TV-85, standard package	2080^{00}
TV-85, optical tube only	1680^{00}
TV-76, standard package	1675^{00}
TV-76, optical tube only	1275^{00}
Pronto, standard package	1120^{00}
Pronto, optical tube only	775^{00}
Ranger, standard package	695^{00}
Ranger, optical tube only	570^{00}

Whether it's the newest telescope or the newest eyepiece, if it's from TeleVue, chances are good we have it in stock. Gibraltar, Panoramic, and TelePod altazimuth mounts; Nagler, Radian, Panoptic, and Plössl eyepieces; Powermates and Barlows; red dot finders; 99% reflectivity Everbrite diagonals; 35mm and digital camera adapters; and more – we have it all. We're TeleVue specialists, and we stock it in depth. Call us and see.

> I received my 6" refractor just one week after I mailed my order to you. Thanks for your fast service! It is a wonderful instrument!
>
> **Customer Quote of the Month #120**

59 SBIG CCD cameras in stock as this was written.

We stock almost all Apogee LISÄÄ, Meade, and SBIG CCD cameras and auto-guiders. We also carry a wide range of CCD accessories – flip mirrors, off-axis guiders, color filter wheels, image processing software, and more. Our large inventory of CCD equipment (59 SBIG cameras alone as this was written) means the chances are good that you won't have to wait to get the SBIG camera or accessories of your choice. Here are the SBIG cameras we keep in stock and their prices.

ST-5C track/accumulate camera	895^{00}
ST-237A track/accumulate camera	1195^{00}
ST-7E self-guiding camera, Class 1	2650^{00}
ST-8E self-guiding camera, Class 1	7350^{00}
ST-8E self-guiding camera, Class 2	5995^{00}
ST-8E self-guiding camera, Class 3	4995^{00}
ST-9E self-guiding camera, Class 1	3950^{00}
ST-10E self-guiding camera, Class 2 only	6995^{00}
ST-1001E large format track/accumulate	6595^{00}
STV digital video camera/guider	1850^{00}
STVD digital video with LCD screen	2250^{00}

Half-price observing books!

Stars and Galaxies
Amateur Astronomy

We bought almost 4000 observing books at some very special prices. We're passing our savings on to you, pricing them as low as 50% off retail. Take a look . . . .

Beginner's Guide to Amateur Astronomy 166 page soft cover, a great way to start, reg. \$14.95 ... **$\$9^{95}$**
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Stars & Galaxies 200 page hard cover, observe 344 of the best deep sky objects, reg. \$29.95 ... **$\$14^{95}$**
Universe From Your Backyard 188 page hard cover, observe 690 deep sky objects, reg. \$29.95 ... **$\$14^{95}$**

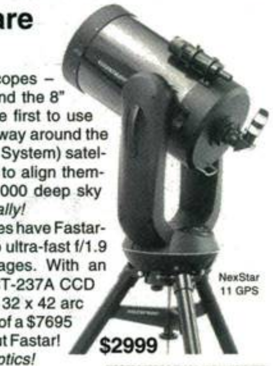
An ETX-90 case, $\$74^{95}$!

The 8" x 15.5" x 18.5" JMI hard case fits the ETX-90RA and the ETX-90EC. Its high density foam interior is diecut to hold scope, four eyepieces, tabletop tripod, T-adapter, and more. Whether for storage or travel, this hard case is a great buy. Regularly \$99.95, we have less than 100 available at this low sale price that saves you 25%.

We also have hard cases available for the Meade LX90 and 10" LX200 plus the Celestron NexStar 4, 5, and 8 and NexStar 11 GPS.

The 8" and 11" NexStar GPS are available from stock.

NexStar 8 GPS $2499



Celestron's go-to computerized scopes – the 11" **NexStar 11 GPS** at \$2999 and the 8" **NexStar 8 GPS** at \$2499 – were the first to use GPS technology to help you find your way around the sky. They use GPS (Global Positioning System) satellites and a built-in electronic compass to align themselves on the sky and locate over 40,000 deep sky objects for you . . . *virtually automatically!*

For CCD astrophotography, both scopes have Fastar-compatible optics that you can convert to ultra-fast f/1.9 and f/2.1 focal ratios for wide field images. With an optional Fastar lens and a \$1295 SBIG ST-237A CCD camera, the 8" GPS will record an huge 32 x 42 arc minute field – over three times the area of a \$7695 CCD camera on the same scope without Fastar! *No other GPS scopes have Fastar optics!*

Compare Celestron go-to prices. Only \$1499 for an 8" . . .

NexStar 8
$1499

Compare the price of this big 8" aperture **Celestron NexStar 8** go-to SCT with other 8" go-to scopes. At only \$1499 – complete with adjustable height tripod, Starbright multicoated optics, red dot finder, 40mm Plössl eyepiece, and a computer with 18,000+ objects in its memory – it's priced hundreds of dollars less than other 8" go-tos. It's enough telescope to keep you busy observing for the rest of your life, at a price that puts 8" aperture go-to astronomy within the reach of practically everyone!

CELESTRON

\$1149 for a 5" . . .

NexStar 5

You get a \$149 value adjustable height aluminum tripod (with built-in equatorial wedge) and a computer control *for free* when you buy a **Celestron NexStar 5** go-to Schmidt-Cassegrain. Compare the price with the price of other 5" go-to scopes (including a tripod and computer) and you'll see that Celestron saves you nearly \$50. NASA uses 5" Celestron optics on the Space Shuttle. Doesn't your observing deserve the same premium quality images?

\$1149

\$599 for a 4" . . .

NexStar 4
$599

The 4000-object computer of the new **Celestron NexStar 4** go-to Maksutov-Cassegrain is standard equipment, not an option as it is with some scopes. The computer's hand control can be used even when docked conveniently in the scope's sleek single fork arm mount. A long eye relief Star Pointer red dot finder makes aligning on the skies a snap. The AA battery-operated tabletop NexStar 4 is so easy to use that you'll be observing only minutes after you take it out of the box. At a mere \$599, *complete,* it's almost \$200 less than competitive 4" go-to Maksutovs.

The Stellarvue refractor, "Hot New Product of 2001."

AT1010CN $\$499^{95}$
with optional diagonal and eyepiece

The 80mm f/6 **Stellarvue AT1010** optical tube was named a "Hot New Product of 2001" in the December 2001 *Sky & Telescope* magazine. Independent reviewers have commented that it competes favorably with ED scopes that cost twice its modest price, and easily outperforms imported achromats in color correction and resolution. Our AT1010CN package includes an extra-long dew shield, three tube baffles for high contrast, triple tested and hand-assembled optics, 2" focuser with 1.25" adapter and T-threads, tube rings, red dot finder, upgraded oversized rubberized focus knobs for easy use in cold weather, and a soft padded carry case. It's in stock.

From $\$10^{\underline{00}}$ to $\$10{,}000^{\underline{00}}$, sell your used telescopes and accessories through the *free* classified ads at www.astrofieds.com

Discovery Dobsonian reflectors start at only \$299.

6" f/8 DHQ, shown with optional eyepiece rack
\$299

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use imported, mass-produced optics that are merely spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. You can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter for only \$49 more!

Premium Dobs from 10" to 17.5" in aperture are also available. For those who need big aperture portability, truss-tube Dobs are available in apertures from 12" to 24".

Here are the Discovery DHQ Dob prices:

6" f/5 Discovery DHQ	$\$299^{00}$	plus \$49 freight
6" f/8 Discovery DHQ	$\$299^{00}$	plus \$49 freight
8" f/6 Discovery DHQ	$\$399^{00}$	plus \$49 freight
8" f/7 Discovery DHQ	$\$399^{00}$	plus \$49 freight
10" f/4.5 Discovery DHQ	$\$599^{00}$	plus \$69 freight
10" f/5.6 Discovery DHQ	$\$599^{00}$	plus \$69 freight

Custom-built Dobs.

Astronomics offers custom-made truss tube Dobsonians hand-crafted in limited quantities by Pete Kron. Pete is a long-time Astronomics customer and is now a full-time member of our staff. Pete has been custom-building Dobs for over 15 years, in sizes up to a 36" f/5, and is known for his exacting quality standards. While Pete specializes in 18" through 24" apertures, custom mirror sizes and focal ratios are also available. He can also upgrade your unwieldy commercially-made Sonotube Dobsonian to an easily transportable truss tube version.

Prices start at \$3500 for a custom-built 18" scope. Converting your commercially-made Sonotube Dob optics to a truss tube mount starts at \$1500 for a 16" f/4.5 scope.

For more information, or to discuss specific pricing, contact Pete via e-mail care of questions@astronomics.com, or by phone toll-free from 9 to 5 Monday through Friday at (800) 422-7876.

24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com
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Messier Marathon

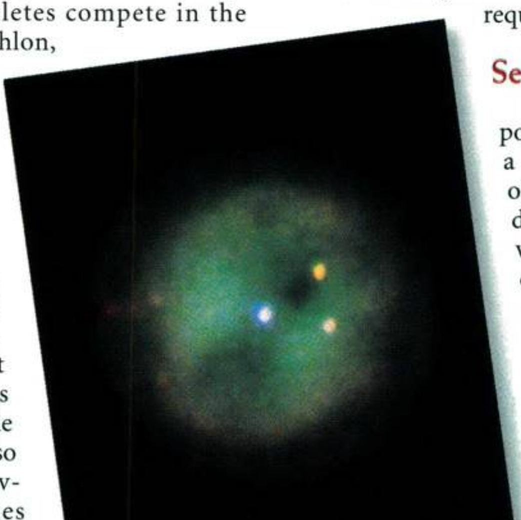
Ready, Set, Go

Once a year, celestial positioning allows for the Messier Marathon, the granddaddy of observing sessions.

by Phil Harrington

Every sport culminates in an ultimate contest to determine the best of the best: for baseball, it's the World Series; for football, the Super Bowl; for hockey, the Stanley Cup. Other athletes compete in the Olympics, the Ironman Triathlon, and the Tour de France. All present challenges of speed and prowess in their respective fields. So how can astronomers test their skills? In a Messier Marathon.

Okay, so astronomy's not exactly a sport, but observers consider viewing all 110 Messier objects a rite of passage. Completion of the list signals that the participant has not only acquired a respectable knowledge of the sky, but is also practiced in the art of observing. It's a task that combines persistence with patience, and one that may take two or more years. In fact, many astronomical societies, including the Astronomical League, issue achievement certificates to all who complete the list, regardless of the timespan involved.



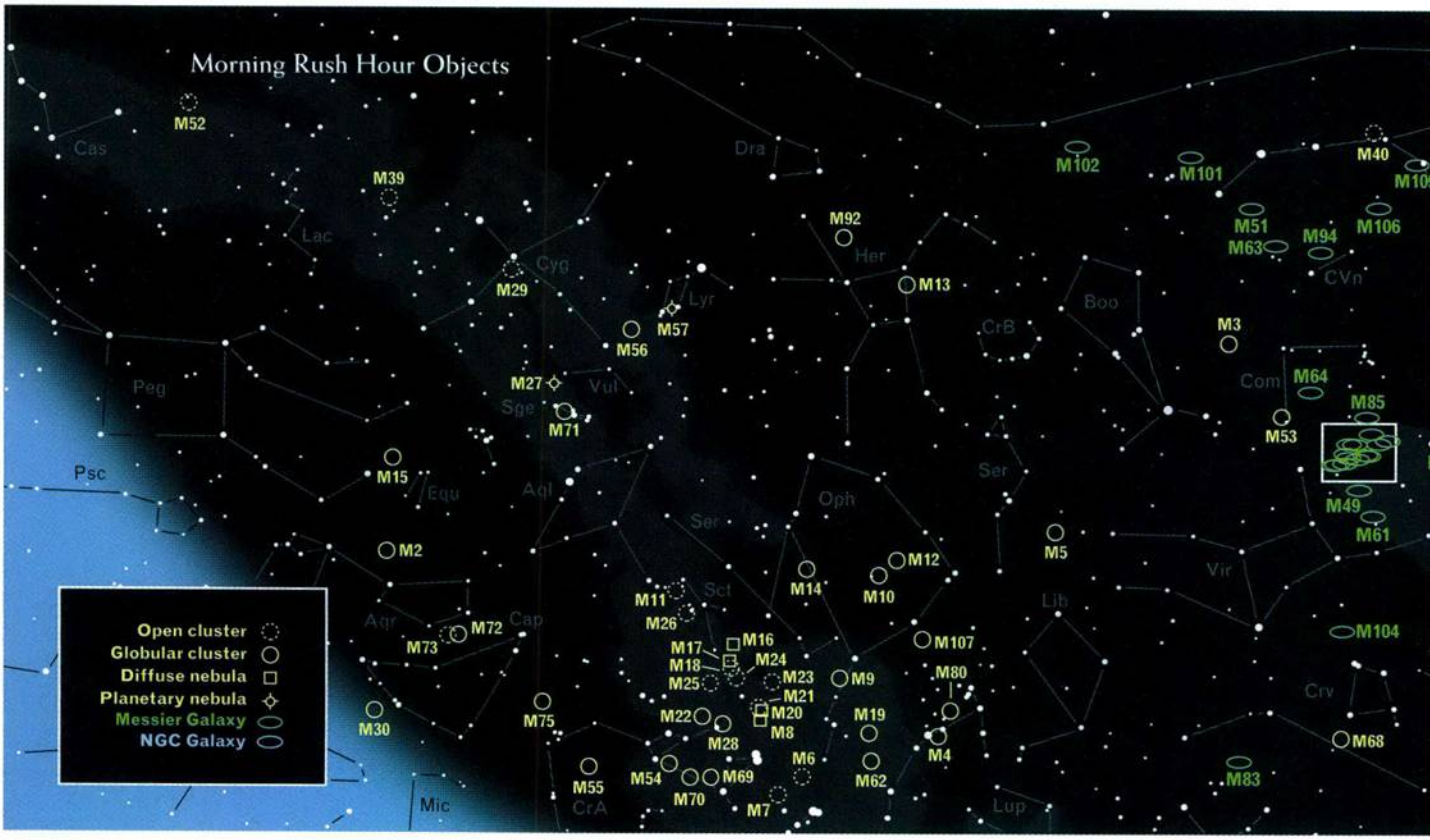
But this begs the question: Just what is the fastest time for completion of this celestial achievement? Final answer: about 12 hours. Once a year — right around the Vernal Equinox — nearly all of the deep-sky objects in Charles Messier's famed catalog are visible sometime during the night, making a Messier Marathon possible. But like any race against the clock, running a successful Messier Marathon requires training and preparation.

Selecting a Site

The single most important point to consider when planning a Messier Marathon is the observing site. Look for clear, dark skies, as well as a good view in all directions — especially toward the southeast, southwest, and northwest. Good sites include golf courses, parks, open fields, and the tops of hills. Check for any nighttime access restrictions to your chosen site. Ask your local astronomy club to see if it plans to run the marathon this year. If not, suggest it. Club marathons are always great fun, as new stargazers get to learn observing tips and tricks first-hand from seasoned veterans. The *Astronomy.com* website lists clubs near

Above: Planetary nebula M97 (the Owl Nebula) is among the faintest of the Messier objects. Tim Hunter and James McGaha

Facing page: Spiral galaxy M33 in Triangulum features pronounced spiral arms that hold globular clusters and "knots" of star-forming regions. Tony and Daphne Hallas


Morning Rush Hour Objects

Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Messier Galaxy
NGC Galaxy
Cas
M52
M39
Lac
Cyg
M29
Peg
Psc
M15
Equ
M2
M27
Sge
Vul
M71
Aql
M56
M57
Lyr
Dra
M92
Her
M13
CrB
Boo
M102
M101
M40
M106
M51
M63
M94
CVn
M3
Com
M64
M53
M85
M49
M61
Vir
M104
Crv
M68
M83
M5
Lib
Ser
Oph
M12
M10
M14
M107
M80
M4
M9
M19
M62
M6
M7
M69
M70
M54
M28
M22
M8
M20
M21
M23
M24
M25
M18
M17
M16
M26
M11
Sct
Ser
M55
CrA
M75
Cap
M72
M73
Aqr
M30
Mic
Lup

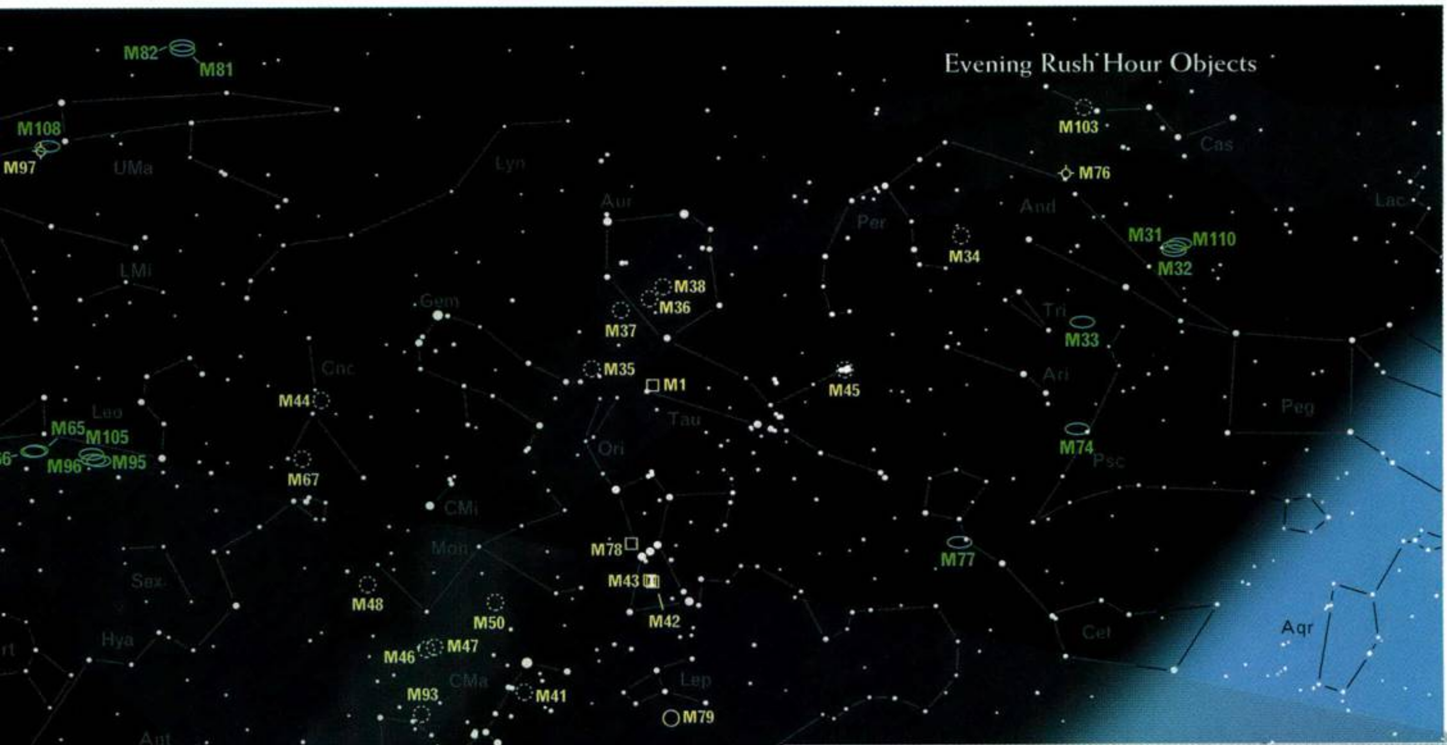
Messier Marathon Planning Guide

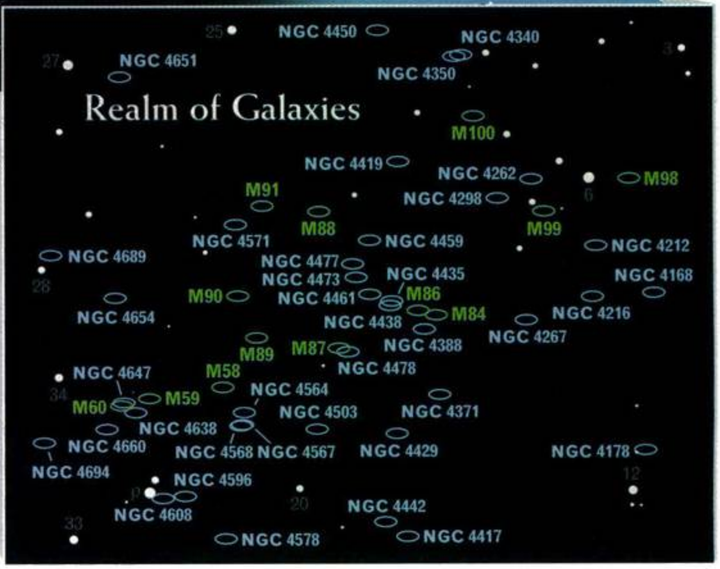
Consider the sequence below as your training guide to a successful completion of a Messier Marathon. Find objects 1 to 5 before twilight ends. Then concentrate on the evening rush hour (objects 6 to 12). Locate morning rush hour objects (101 through 109) just as dawn begins stealing back the night. Very diligent observers with sharp eyes who are positioned at a latitude of 35° N or lower may catch a glimpse of the elusive M30, the last object (#110) on the list.

Key to types: OC: open cluster; BN: bright nebula; Gx: galaxy; GC: globular cluster; PN: planetary nebula; SNR: supernova remnant; IG: irregular galaxy; DS: double star; AS: asterism.

(Sizes are listed in arcminutes unless otherwise noted.)

Seq#	M	NGC	Con.	Type	R.A.	Dec.	Mag.	Size
1	M45	—	Tau	OC	3h47.0m	24°07'	1.2	110'
2	M42	1976	Ori	BN	5h35.4m	–5°27'	—	65' by 60'
3	M43	1982	Ori	BN	5h35.6m	–5°16'	—	20' by 15'
4	M41	2287	CMa	OC	6h47.0m	–20°44'	4.5	38'
5	M35	2168	Gem	OC	6h08.9m	24°20'	5.1	28'
6	M31	224	And	Gx	0h42.7m	41°16'	3.4	185' by 75'
7	M32	221	And	Gx	0h42.7m	40°52'	8.1	11' by 7'
8	M110	205	And	Gx	0h40.4m	41°41'	8.1	20' by 13'
9	M77	1068	Cet	Gx	2h42.7m	–0°01'	8.9	8' by 7'
10	M33	598	Tri	Gx	1h33.9m	30°39'	5.7	67' by 42'
11	M79	1904	Lep	GC	5h24.5m	–24°33'	7.8	9'
12	M74	628	Psc	Gx	1h36.7m	15°47'	9.4	11' by 11'
13	M76	650–1	Per	PN	1h42.4m	51°34'	10.1	65"
14	M52	7654	Cas	OC	23h24.2m	61°35'	6.9	12'
15	M103	581	Cas	OC	1h33.2m	60°42'	7.4	6'
16	M34	1039	Per	OC	2h42.0m	42°47'	5.2	35'
17	M38	1912	Aur	OC	5h28.7m	35°50'	6.4	21'
18	M36	1960	Aur	OC	5h36.1m	34°08'	6.0	12'
19	M37	2099	Aur	OC	5h52.4m	32°33'	5.6	20'
20	M1	1952	Tau	SNR	5h34.5m	22°01'	—	6' by 4'
21	M78	2068	Ori	BN	5h46.7m	0°03'	—	8' by 6'
22	M50	2323	Mon	OC	7h03.2m	–8°20'	5.9	16'
23	M47	2422	Pup	OC	7h36.6m	–14°30'	4.4	29'
24	M46	2437	Pup	OC	7h41.8m	–14°49'	6.1	27'
25	M93	2447	Pup	OC	7h44.6m	–23°52'	6.2	22'
26	M48	2548	Hya	OC	8h13.8m	–5°48'	5.8	54'
27	M44	2632	Cnc	OC	8h40.1m	19°59'	3.1	95'
28	M67	2682	Cnc	OC	8h51.3m	11°50'	6.9	29'
29	M81	3031	UMa	Gx	9h55.6m	69°04'	6.9	24' by 13'
30	M82	3034	UMa	IG	9h55.8m	69°41'	8.4	12' by 6'
31	M108	3556	UMa	Gx	11h11.5m	55°40'	10.0	8' by 2'
32	M97	3587	UMa	PN	11h14.8m	55°01'	9.9	194"
33	M109	3992	UMa	Gx	11h57.6m	53°23'	9.8	8' by 4'
34	M40	WNC 4	UMa	DS	12h22.4m	58°05'	9.1	50"
35	M106	4258	CVn	Gx	12h19.0m	47°18'	8.4	20' by 8'
36	M94	4736	CVn	Gx	12h50.9m	41°07'	8.2	13' by 11'
37	M63	5055	CVn	Gx	13h15.8m	42°02'	8.6	14' by 8'
38	M51	5194	CVn	Gx	13h29.9m	47°12'	8.4	8' by 7'
39	M101	5457	UMa	Gx	14h03.2m	54°21'	7.9	26' by 26'
40	M95	3351	Leo	Gx	10h44.0m	11°42'	9.7	8' by 5'
41	M96	3368	Leo	Gx	10h46.8m	11°49'	9.2	7' by 5'
42	M105	3379	Leo	Gx	10h47.8m	12°35'	9.3	4' by 4'
43	M65	3623	Leo	Gx	11h18.9m	13°05'	9.3	9' by 2'
44	M66	3627	Leo	Gx	11h20.2m	12°59'	8.9	8' by 4'
45	M98	4192	Com	Gx	12h13.8m	14°54'	10.1	9' by 2'
46	M99	4254	Com	Gx	12h18.8m	14°25'	9.9	5' by 4'
47	M100	4321	Com	Gx	12h22.9m	15°49'	9.3	6' by 5'
48	M85	4382	Com	Gx	12h25.4m	18°11'	9.1	8' by 6'
49	M60	4649	Vir	Gx	12h43.7m	11°33'	8.8	7' by 6'
50	M59	4621	Vir	Gx	12h42.0m	11°39'	9.6	5' by 4'
51	M58	4579	Vir	Gx	12h37.7m	11°49'	9.7	6' by 5'
52	M89	4552	Vir	Gx	12h35.7m	12°33'	9.8	3' by 3'
53	M87	4486	Vir	Gx	12h30.8m	12°24'	8.6	7' by 7'
54	M84	4374	Vir	Gx	12h25.1m	12°53'	9.1	5' by 4'
55	M86	4406	Vir	Gx	12h26.2m	12°57'	8.9	12' by 9'
56	M90	4569	Vir	Gx	12h36.8m	13°10'	9.5	11' by 4'


Evening Rush Hour Objects
M82
M81
M108
M97
UMa
Lyn
Aur
Per
And
M103
M76
Cas
Lac
LMi
M34
M31
M110
M32
M38
M36
Gem
M37
Tri
M33
Cnc
M35
M1
M45
Ari
M44
Leo
M65
M105
M96
M95
Tau
Peg
M74
Psc
M67
Ori
CMi
Mon
M78
M43
M77
Sex
M48
M42
M50
Hya
M46
M47
Cet
Aqr
M93
CMa
M41
Lep
M79
Ant
Pyx
Col


Realm of Galaxies
25
NGC 4450
NGC 4340
27
NGC 4651
NGC 4350
M100
NGC 4419
NGC 4262
M98
M91
NGC 4298
6
M88
M99
NGC 4571
NGC 4459
NGC 4212
NGC 4689
NGC 4477
NGC 4435
NGC 4168
28
NGC 4473
M86
M90
NGC 4461
NGC 4654
M84
NGC 4216
NGC 4438
NGC 4267
M89
M87
NGC 4388
NGC 4647
M58
NGC 4478
34
NGC 4564
M60
M59
NGC 4503
NGC 4371
NGC 4638
NGC 4660
NGC 4568
NGC 4567
NGC 4429
NGC 4178
NGC 4694
12
NGC 4596
20
NGC 4442
NGC 4608
33
NGC 4578
NGC 4417

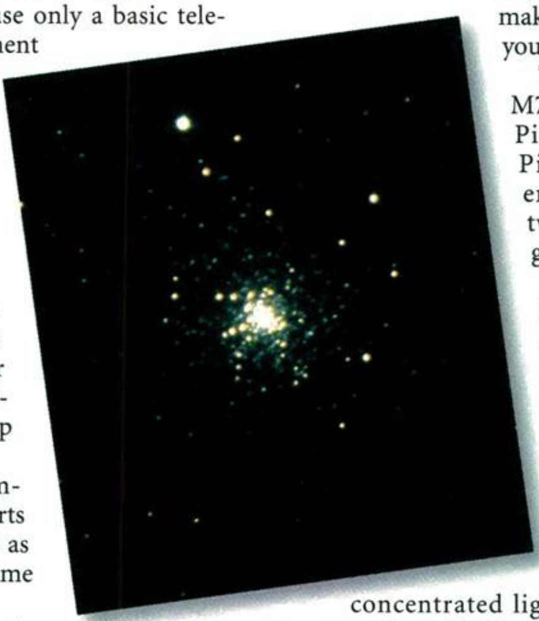
Seq#	M	NGC	Con.	Type	R.A.	Dec.	Mag.	Size
57	M91	4548	Com	Gx	12h35.4m	14°30'	10.2	5' by 4'
58	M88	4501	Com	Gx	12h32.0m	14°25'	9.6	6' by 3'
59	M49	4472	Vir	Gx	12h29.8m	8°00'	8.4	8' by 7'
60	M61	4303	Vir	Gx	12h21.9m	4°28'	9.7	6' by 6'
61	M53	5024	Com	GC	13h12.9m	18°10'	7.5	13'
62	M64	4826	Com	Gx	12h56.7m	21°41'	8.5	9' by 5'
63	M3	5272	CVn	GC	13h42.2m	28°23'	5.9	16'
64	M104	4594	Vir	Gx	12h40.0m	–11°37'	8.0	7' by 4'
65	M68	4590	Hya	GC	12h39.5m	–26°45'	7.7	12'
66	M83	5236	Hya	Gx	13h37.0m	–29°52'	7.6	16' by 13'
67	M5	5904	Ser	GC	15h18.6m	2°05'	5.7	17'
68	M102	5866	Dra	Gx	15h06.5m	55°46'	9.9	7' by 3'
69	M13	6205	Her	GC	16h41.7m	36°28'	5.7	17'
70	M92	6341	Her	GC	17h17.1m	43°08'	6.4	11'
71	M12	6218	Oph	GC	16h47.2m	–1°57'	6.8	15'
72	M10	6254	Oph	GC	16h57.1m	–4°06'	6.6	15'
73	M14	6402	Oph	GC	17h37.6m	–3°15'	7.6	12'
74	M107	6171	Oph	GC	16h32.5m	–13°03'	8.1	10'
75	M4	6121	Sco	GC	16h23.6m	–26°32'	5.8	26'
76	M80	6093	Sco	GC	16h17.0m	–22°59'	7.3	9'
77	M62	6266	Oph	GC	17h01.2m	–30°07'	6.7	14'
78	M19	6273	Oph	GC	17h02.6m	–26°16'	6.7	14'
79	M9	6333	Oph	GC	17h19.2m	–18°31'	7.6	9'
80	M6	6405	Sco	OC	17h40.1m	–32°13'	4.2	33'
81	M7	6475	Sco	OC	17h53.9m	–34°49'	3.3	80'
82	M8	6523	Sgr	BN	18h03.8m	–24°23'	—	45' by 30'
83	M20	6514	Sgr	BN	18h02.3m	–23°02'	—	20' by 20'
84	M21	6531	Sgr	OC	18h04.6m	–22°30'	5.9	13'
85	M23	6494	Sgr	OC	17h56.8m	–19°01'	5.5	27'
86	M24	—	Sgr	OC	18h18.4m	–18°25'	4.5	120' by 40'
87	M18	6613	Sgr	OC	18h19.9m	–17°08'	6.9	10'
88	M25	IC 4725	Sgr	OC	18h31.6m	–19°15'	4.6	32'
89	M17	6618	Sgr	BN	18h20.8m	–16°11'	—	20' by 15'
90	M16	IC 4703	Ser	BN	18h18.6m	–13°58'	—	35' by 28'
91	M22	6656	Sgr	GC	18h36.4m	–23°54'	5.1	24'
92	M28	6626	Sgr	GC	18h24.5m	–24°52'	6.8	11'
93	M11	6705	Sct	OC	18h51.1m	–6°16'	5.8	13'
94	M26	6694	Sct	OC	18h45.2m	–9°24'	8.0	14'

Seq#	M	NGC	Con.	Type	R.A.	Dec.	Mag.	Size
95	M57	6720	Lyr	PN	18h53.6m	33°02'	8.8	71"
96	M56	6779	Lyr	GC	19h16.6m	30°11'	8.3	7'
97	M39	7092	Cyg	OC	21h32.2m	48°26'	4.6	31'
98	M29	6913	Cyg	OC	20h23.9m	38°32'	6.6	6'
99	M27	6853	Vul	PN	19h59.6m	22°43'	7.3	348"
100	M71	6838	Sge	GC	19h53.8m	18°47'	8.0	7'
101	M69	6637	Sgr	GC	18h31.4m	–32°21'	7.6	7'
102	M70	6681	Sgr	GC	18h43.2m	–32°18'	8.0	8'
103	M54	6715	Sgr	GC	18h55.1m	–30°29'	7.6	9'
104	M55	6809	Sgr	GC	19h40.0m	–30°58'	6.4	19'
105	M75	6864	Sgr	GC	20h06.1m	–21°55'	8.5	6'
106	M15	7078	Peg	GC	21h30.0m	12°10'	6.0	12'
107	M2	7089	Aqr	GC	21h33.5m	–0°49'	6.4	13'
108	M72	6981	Aqr	GC	20h53.5m	–12°32'	9.3	6'
109	M73	6994	Aqr	AS	20h59.0m	–12°38'	8.9	3'
You must be observing from south of latitude 35° north to see M30 in March.								
110	M30	7099	Cap	GC	21h40.4m	–23°11'	7.3	11'

you. Or, you can visit my Dark-Sky Site Directory at http://www.philharrington.net.

Size Doesn't Matter

After you've selected a site, let's talk telescopes. Don't buy a new telescope for the Messier Marathon. Instead, stick with equipment that you know and love. Messier used a 6-inch telescope when he originally cataloged the objects. Telescope size and type don't really matter, because many Messier objects are bright enough to be seen with binoculars.



Traditional Messier Marathoners use only a basic telescope, not a computer-driven instrument or one with digital or mechanical setting circles. And so I encourage you to face the challenge by using only your sky knowledge and basic equipment: your eyes, a star atlas, binoculars, and a telescope.

Arm yourself with a good finderscope; an 8x50 or larger works best. Search for the objects using a wide-field, low-power eyepiece (25mm to 55mm). Confirm smaller, fainter Messier objects with a medium focal-length eyepiece (12mm to 20mm). Keep your high-power eyepiece in its case.

Invest in a good star atlas. I recommend *Sky Atlas 2000.0*. Each of its charts shows both a wide slice of sky as well as stars to magnitude 8.5 — about the same as seen through an 8x50 finder.

Some observers prefer not to use a star atlas at all. These veterans know the sky so well that they run a memorized Messier Marathon.

Consider a dress rehearsal before attempting the full marathon to determine what works and what doesn't. The new moon on the evening of Monday, February 11, 2002 (in North America) provides an ideal opportunity for a dry run. That gives you four weeks to correct any glitches or update your equipment.

It is crucial that you enter the marathon with a prepared finding sequence. Stick to it. A marathon table appears on pages 66 and 67 for your convenience.

Checking it Twice

Tonight is the night: You've found a great observing site and double-checked your packing list. Arrive at your observing site before sunset. Organize your set-up so that you can find things in the dark.

Next, check the telescope's collimation. Then sit back and enjoy the sunset. Slowly, a few of the brighter stars will begin to peek out from the deep-blue sky.

Look southwest for the brilliant planet Venus. In short order you'll see Jupiter high in the western sky, and then the star Sirius in the south. Next, perhaps, comes Rigel, followed quickly by Betelgeuse, Procyon, Capella, and Saturn. Soon more and more stars spangle the sky. The starter's pistol has been fired; the race is on.

Unlike many marathoners, who wait for what I call the evening "rush-hour" objects, I recommend beginning with the easy ones, like the Pleiades (M45) and the Orion Nebula (M42 and M43). Both are readily visible long before the sky is fully dark. If there is still time, take aim at some of the bright open star clusters in Auriga and Gemini — M35 through M38 — but don't spend too much time on these. They'll be visible for hours.

As the sky darkens, switch your attention over to the evening rush-hour objects, which drop out of sight shortly after darkness. These include M31, M32, M33, M74, M77, M79, and M110, and are highlighted in the finding sequence chart. Allow yourself five minutes to locate these. If one eludes you, don't waste too much valuable time looking for it. Instead, move on to the next, but make a mental note to return later, if your schedule permits.

The most difficult of the lot is M74, a faint, face-on spiral galaxy in Pisces. Spotting the constellation Pisces from a dark sky is tough enough, let alone in a darkening twilight sky; finding a large, dim galaxy in it is truly formidable.

Here's a hint: Forget Pisces. Instead, use the brighter stars of Aries the Ram as locator guides. The stars Hamal (Alpha Arietis) and Sheratan (Beta Arietis) in Aries point right at the faint star Eta Piscium in Pisces, and M74 lies nearby.

M77 in Cetus is also a tough catch, although a bit more obvious than M74, thanks to its more concentrated light. Be aware that these two are common misses. But just because you skip them, don't call it a night. Keep going — you still need to find another 108 objects on the list.

With the evening rush-hour objects behind, take a deep breath. It's easy to build up a sweat even if the temperature is near freezing. With the calm of a seasoned athlete, continue through the winter constellations, pausing momentarily — but purposely — at such wonders as open clusters M41, M93, M46, and M47. All are dazzling, especially on clear late-winter evenings. If this is your first time past these, or any of the other Messier objects, be sure to return the next chance you get for a more leisurely visit.

Before midnight, the stars of spring are replacing those of winter, bringing forth a new set of Messier challenges. To the north are the magnificent galaxies M51, M81, and M82, while to the south await Leo's remarkable quintet of M65, M66, M95, M96, and M105.

Entering the Realm

Sometime around 1 A.M., you should have already completed the galaxies that litter Leo and Ursa Major. Just as your confidence builds, you round the bend to face what might be called the marathon's "Heartbreak Hill" — the Coma-Virgo Realm of Galaxies. The Realm of Galaxies contains no fewer than 14 Messier objects within a 45-square-degree area. Nowhere in the entire sky are so many Messier objects packed into such a small region. To compli-

Above: Only observers stationed south of 35° north latitude can view the elusive M30 (a faint globular cluster) in Capricornus. Jack Newton
Facing page: The Pleiades (M45), visible very early in the evening, is among the easiest Messier Marathon objects to find. Gerald Rhemann

Facing page: A cluster of about 35 bright but obscured stars is embedded in the Omega Nebula. Gerald Rhemann and Franz Kersche
Below: The giant elliptical galaxy M87 dominates the core of the nearby Virgo cluster. Jack Newton

cate things, there are dozens of other galaxies here that belong to the *NGC*, or *New General Catalog*. Although they were too faint for Messier to spot, many are probably bright enough to be seen through your telescope. How can you tell them apart?

Don't panic — and don't use *Sky Atlas 2000.0*. Instead, consult the chart that accompanies this article. You must enter the Realm slowly. I find that a direct assault in two waves — western and eastern — works best.

For the western attack, begin at the star Denebola in the triangle of Leo the Lion. From there, move one finderscope field (about 7°) due east, to a small triangular asterism formed by four faint stars. The northernmost star also forms part of a diamond pattern seen just to the north. From there, you can pick off M98, M99, M100, and M85.

The eastern assault of the Realm begins from the star Vindemiatrix (Epsilon Virginis) in Virgo. Follow a path about one finderscope field due west, where you will be greeted by a pair of suns, including 5th-magnitude Rho Virginis and a fainter, 7th-magnitude star. To their north are M60, M59, M58, M89, M87, M84, M86, M90, M91, and M88. It's easiest to find M49 and M61 by moving from Vindemiatrix to Rho. Trace an arc of stars to the southwest for M49, then look through your finderscope farther south for a wide triangle of dim stars. M61 lies within.

Whatever your method for treading through the Realm, don't forget to pause and enjoy the many *NGC* and *IC* galaxies along the way.

After the Realm is conquered, breathe a sigh of relief: The hard part is over. Your local time is probably about 2 A.M., and the stars of summer are rising in the east, bringing with them such wonderful deep-sky treasures as M8, M11, M13, M17, M22, and M57. Linger but a moment — within two hours, dawn's first light will begin stealing back the night. Work your way from north to south along the Milky Way. You should get to Sagittarius around 3:30 A.M. The marathon is now coming down the home stretch.

Objects in western Sagittarius and Scorpius are well up in the southeastern sky. Those in southern and eastern Sagittarius may cause problems. Pause quickly at M54, M69, and M70 along the bottom of the Sagittarius teapot, then hurry toward globular clusters M55 and M75 in the constellation's eastern quadrant. Finally, race into Aquarius for M2, and then northward to M15 in Pegasus.

With birds chirping to herald the coming dawn, try your best for M72 and M73. First, the dimmest glow of the 9th-magnitude globular M72 comes into view. Once nabbed, grapple for the four faint stars that make up M73, one of the least impressive Messier objects.

For marathon participants positioned above 35° north latitude, viewing M30 is impossible; observers south of that line may catch a glimpse of this faint globular (in Capricornus) shortly before the sky brightens. To those who see it, I tip my hat.

And so the Messier Marathon is an athletic event of sorts: Participants race around the sky like maniacs for a whole night only to end up where they started. It proves nothing, skeptics say. But I beg to differ. The Messier Marathon does prove something very important: Astronomy is fun.

On your mark, get set . . .

Phil Harrington is a seasoned observer with several Messier Marathon notches on his various telescopes. He encourages visits to his website at www.philharrington.net.

Future Messier Marathon Dates

Year	New Moon Date	Best Marathon Weekend around Vernal Equinox
2002	March 14	March 16
2003	March 3, April 1	March 8 or March 29
2004	March 21	March 20
2005	March 10	March 12
2006	March 29	March 25 or April 1
2007	March 19	March 17
2008	March 7, April 6	March 8 or March 29
2009	March 26	March 28
2010	March 15	March 13 or March 20
2011	March 4, April 3	March 5 or April 2

Marathon Materials

Here are my suggestions for equipment and other items that you will need to compete in a Messier Marathon. Remember to dress for the conditions and expect to spend a full night under the stars.

Binoculars
Telescope
Eyepieces
Star atlas or finder charts
Planning guide for the Messier Marathon
Red flashlight
Clipboard
Pen or pencil
Wristwatch or clock
Cold-weather clothing
Chemical foot and hand warmers
Chair or stool
Table
Thermos of coffee, tea, or hot chocolate, and some munchies
Tissue or napkins

ask Astro

Nearby Supernovae, Super-Earths, Facing the Moon

To appear as bright as the sun, Supernova 1987A (lower right) would have had to be closer than 1 light-year from Earth. NOAO

At what distance from Earth would a supernova have to be located to have the same apparent magnitude as the sun? At that distance would it pose a significant danger to life on Earth? *— David Murray, Portsmouth, United Kingdom*

Supernovae produce far different proportions of visible light, x rays, gamma rays, and charged particles than our sun does, and the amount of these emissions changes with time as the explosion proceeds and the supernova's ejecta expands into space. To complicate things further, there are several kinds of supernovae and their intrinsic brightnesses differ somewhat. As a result, there's no single answer to this question. However, if we limit ourselves to considering just the visible light produced during the brightest part of the explosion, we can calculate the distance at which a supernova would have the same apparent brightness as our sun. The distances turn out to be surprisingly small: about 1 light-year (0.3 parsec) for a Type Ia supernova — a white dwarf in a binary system that accretes too much mass from its companion — and about two-thirds of a light-year (0.2 parsec) for a Type II supernova — a massive star that collapses after exhausting the nuclear fuel in its core. So for a supernova to rival the sun in visual brightness, it would have to lie closer than the nearest normal star.

It proves somewhat more difficult to determine the distance at which a supernova would constitute a serious danger to life. The answer depends a bit on what life you're concerned about and whether you're more worried about death by photon (visible light, x rays, gamma rays), death by neutrino, or death by high-velocity ion. For humans, the biggest hazards to life most likely come from the high-energy gamma rays produced by the decay of radioactive nuclei, like nickel-56, in the ejecta of a Type Ia supernova.

Even at a distance of a few thousand light-years, the radiation from such gamma rays could rival the dose received at Earth from solar flares, even during the sun's most active periods. This suggests that the gamma radiation from supernovae might be dangerous at distances well beyond the few tens of light-years that neutrinos and ions would pose a meaningful hazard. Although it's hard to pick a single distance at which a supernova constitutes a significant hazard, our advice would be to stay well away if you have the option.

To delve deeper into this subject, visit the website created by Michael Richmond at http://a188-l009.rit.edu/richmond/answers/snrisks.txt. It presents calculations for estimating these kinds of risks to life on Earth as well as several interesting references. — *Scott Sandford and Jesse Bregman, NASA-Ames Research Center, Moffett Field, California (http://web99.arc.nasa.gov/~astrochm/)*

What is the upper mass limit and size limit for rocky planets, like those in the inner solar system? Could there be other systems out there with big, rocky planets? *— Bill Browning, Brooklyn, New York*

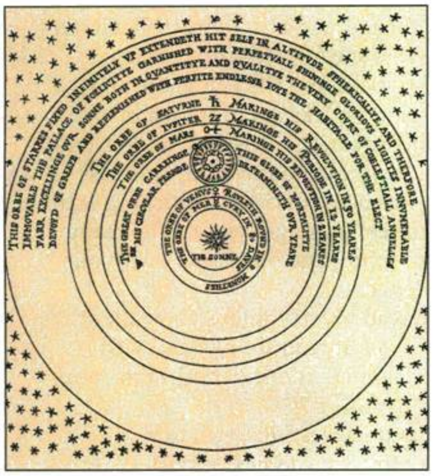
The current theory of planet formation starts with dust particles orbiting in a flattened disk around a young star. The dust particles collide and stick together, growing ever larger, eventually reaching the sizes of asteroids, moons, and rocky planets. The resulting rocky planets can grow as large as 10 or 20 times the mass of Earth and have diameters several times that of Earth. These "Super-Earths" would have enough mass that they could be detected by the Doppler effect, just as the big extrasolar planets are already found. — *Geoff Marcy, University of California at Berkeley*

Who was the first to figure out that stars were like the sun and not fixed fires on the celestial sphere? — *Dan Dorritie, Davis, California*

In 1576 the English astronomer Thomas Digges published a diagram of the Copernican system with the stars labeled: "This orbe of starres fixed infinitely up extendeth hit self in altitude sphericallye, and therefore immovable, the pallace of foelicitye garnished with perpetuall shininge glorious lightes innumerable farr excellinge our sonne both in quantitye and qualitye." Although some researchers have taken this as a hint that he considered the stars to be suns, most have credited Descartes with establishing this idea.

The first persons to put the concept to practical use, at the end of the 17th century, were James Gregory, Isaac Newton, and Christiaan Huygens. Each independently used the notion that "faintness means farness" to estimate the distance to Sirius based on the assumption that this star was like the sun. — *Owen Gingerich, Harvard-Smithsonian Center for Astrophysics*

English astronomer Thomas Digges may have been the first to imply that distant stars were objects similar to the sun.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THE GREAT ORBE CARRYINGE THIS GLOBE OF MORTALITYE
THE SONNE

The same side of the moon always faces Earth. Is this the case with any other moons in our solar system? — *Lawrence Silverman, Plymouth, Massachusetts*

The synchronous rotation of the moon to Earth did not happen by chance but results from the gravitational interaction between the two bodies. The strength of gravity depends heavily on distance, so the moon's gravity pulls stronger on the side of Earth facing the moon than on the farside. This so-called differential force across Earth creates a "tidal" bulge in our planet fixed with respect to the moon that gives rise to the tides we see in Earth's oceans.

Because Earth does not rotate synchronously with the moon, the tidal bulge moves around Earth as it rotates under the moon. The heating of Earth's interior from this repeated flexing and friction between the crust, oceans, and Earth's interior dissipates a lot of energy.

This energy loss slows Earth's rotation at a current rate of about 1 second every 500 years. Because the Earth-moon system must conserve angular momentum, the moon is moving away from Earth by about 4 centimeters (a little over an inch) per year. Earth will continue to spin down slowly until it becomes tidally "locked" to the moon and thus also rotates synchronously. The same forces described above have acted on the moon, but because Earth has much more mass, the forces were stronger and thus faster in slowing the moon's spin to synchronous rotation with Earth. This then stopped any energy dissipation in the moon.

These processes occur throughout the solar system, so it shouldn't be any surprise that astronomers have found synchronous rotation between moons and their respective planets to be the norm and not the exception. The closer a moon lies to its planet and the more mass that planet possesses, the faster the moon will become a synchronous rotator. Jupiter's moon Io is an extreme case in which the tidal energy dissipated in its interior has heated the moon tremendously and caused widespread volcanism. The Pluto-Charon system has already reached double synchronicity, with Charon keeping the same face to Pluto while Pluto keeps the same face to Charon — the eventual fate of the Earth-Moon system.

Earth always sees the same side of the moon.

T. A. Rector, I. P. Dell'Antonio/NOAO/AURA/NSF

Synchronous rotation doesn't happen just between moons and planets but can occur anywhere that two bodies orbit each other. For example, Mercury's rotation has been coupled to the sun, and astronomers have found stars in some binary systems that rotate synchronously. — *Scott S. Sheppard, Institute for Astronomy, University of Hawaii* ▪

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live.

Beginner's sky

Diary of a neophyte astronomer. By Jerry Burstein

Above: Castor and Pollux (left blue and white stars, respectively) dominate the constellation Gemini the Twins. Bill and Sally Fletcher

Facing page: Cepheus the King sports a distinctive, house-shaped asterism . Bill and Sally Fletcher

I've never been one of those parents who videotapes every eventful moment my kid experiences. When it comes to our stargazing adventures, though, we've been conscientiously keeping a journal and making sketches that track our progress. (A moon drawing got raves from classmates and teachers.)

Despite the cold weather, we're concentrating on learning to use star charts to identify planets, constellations, and asterisms — or picture-like star groups within constellations (the "Big Dipper," in Ursa Major). Sometimes the journal entries are as simple as the names of objects we've identified, such as Saturn, Gemini, House (not ours, but an asterism in Cepheus), and the North Star — Polaris. What's neat is that my seven-year-old daughter remembers what and where things are by using the star chart to help visualize what we're seeing (and for correct spellings) — and then writes them down.

My first impression of star charts was "Man, this looks complicated. And why is east on the left and west on the right?" We're using *Astronomy*'s center spread star map. I also bought a basic star guide that's been a big help. After reading the instructions, I quickly realized that you're supposed to face south while lifting the charts over your head. And, as reader Jerry Vogwill of Allentown, Pennsylvania, points out, we must remember that things are a lot more spread out in the sky than on the star chart.

Sidekick loved painting a flashlight with Mom's red nail polish to help us keep our dark-adaption eyesight while reading the chart outside at night. We used the position of the moon and compared it with *Astronomy*'s "Path of the Planets" chart. I was amazed when my daughter remembered that you could visually draw a line from the two stars on the end of the Big Dipper's bucket to locate Polaris (the last star on the tail of the Little Dipper in Ursa Minor). Once we found those, we used the chart to pinpoint other objects.

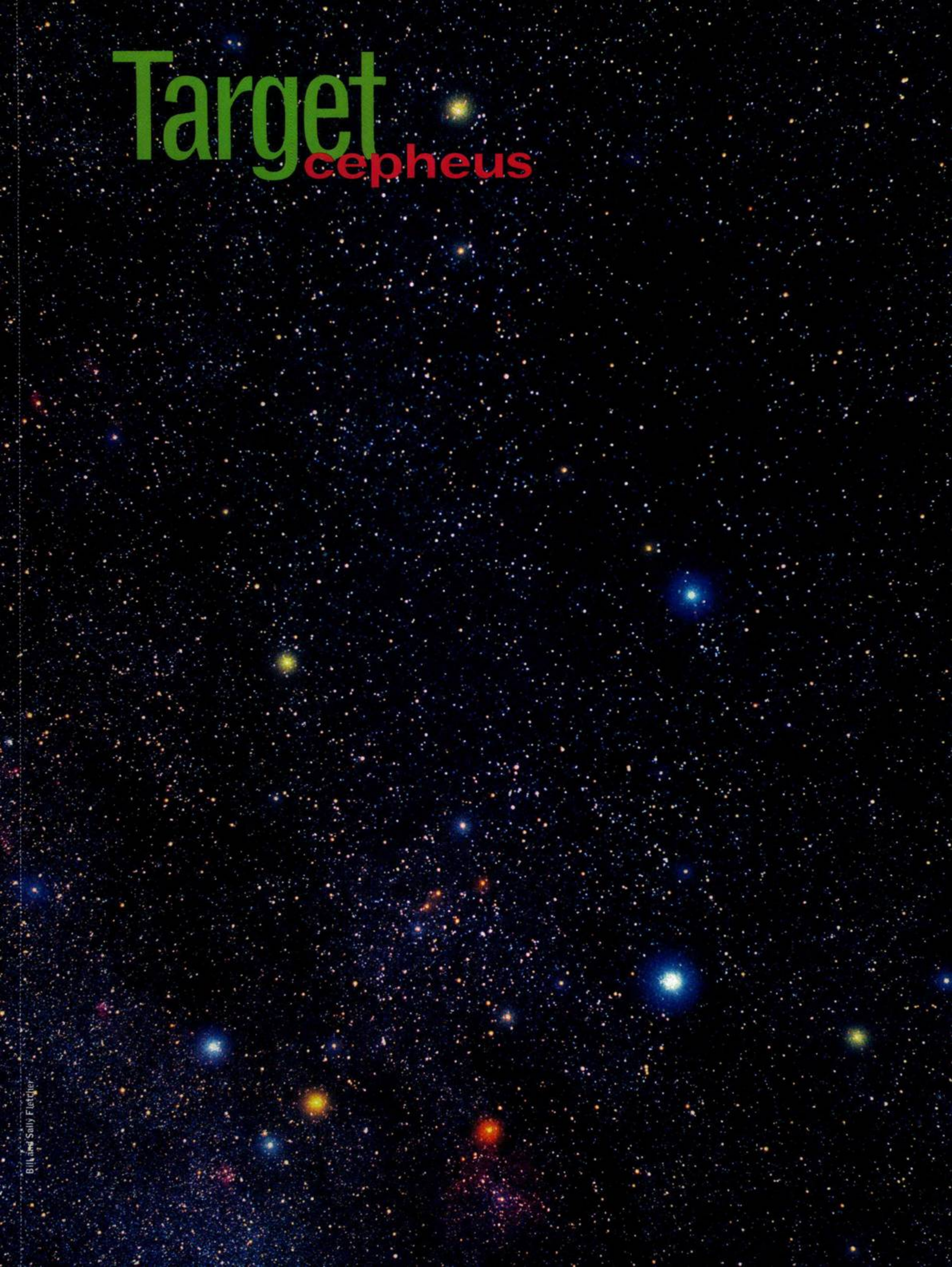
Cepheus is easy to spot because the top star of the "roof" lies only a short distance from Polaris. Another adventure started when Sidekick saw Draco the Dragon on the chart. We spotted its diamond-shaped head, but the tail was a bit more difficult. Of course, the kid swears she saw it — no problem.

We also found Capella and the Pentagon, and Orion — where again we learned to trace a line from its belt to find Sirius, the Dog Star, and several more. Aside from the cold and too many overcast nights, stargazing has been lots of fun. Sticking with easy ones makes us feel more successful. The really neat part has been impressing our friends with our new-found knowledge.

It was a kick to read my daughter's entry the night after a sleep-over. It read simply, "Showed Brittany some stars I knew and she thinks I'm cool."

Keep sending your suggestions, etc., to jerry@astronomy.com. See you next month.

Target
cepheus



Bill and Sally Fletcher

Beginner's helpful tips

What you need to know but don't know how to ask about telescopes.

Once the astronomy bug bites you, it's hard to stop yourself from running out and buying the first telescope you see. After all, if an object looks interesting to your naked eyes and even more intriguing through binoculars, it's got to pop in a telescope. Chances are it will — but if you're going to adopt astronomy as your new hobby, do it right.

Devote a few minutes now and learn some basic telescope information you'll need to make an educated purchase. That way, you won't regret that the salesperson talked you into an instrument beyond your capabilities.

Refractors Versus Reflectors

Refractors are what most people picture when they hear the word telescope. Think of the traditional tube with an eyepiece at the bottom end. Galileo used the first one to spot lunar craters, Saturn's rings, and Jupiter's moons. His original scope probably magnified about 30 times. Modern refractors feature the same basic design but have better optics and removable eyepieces.

Reflectors, on the other hand, incorporate one or more mirrors to bounce an image to the eyepiece, which is mounted near the front end of the scope. Isaac Newton invented the reflector in 1672. Newtonian scopes use a flat secondary mirror to reflect the image sideways, into an eyepiece.

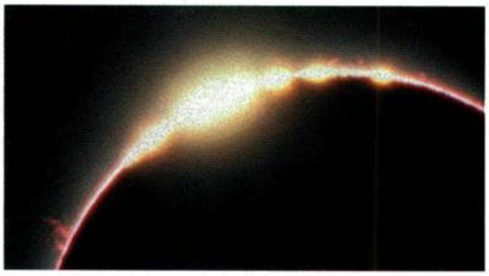
Then, just when you think you've got this nailed, the salesperson mentions a third type: the catadioptric telescope. Face this challenge with the knowledge that Cassegrain, Maksutov, and other catadioptric scopes use mirrors and lenses to form images in a compact tube package.

Shop for a Name-brand Telescope

Quality is comparable for name-brand scopes, so it comes down to a matter of preference. Look at the size, weight, and shape — which translates into portability — of each telescope to help decide what you want in an observing tool.

In any case, don't let your eyes glaze over when you hear the words aperture, focal length, and focal ratio — or f/number. You really can keep this all straight: remember that telescope size equals aperture (diameter of the lens or mirror). Focal length is simply the distance between the mirror or lens and where the image comes to focus. Determine focal ratio (f/number) of the telescope by dividing its focal length (say, 40 inches) by its aperture (say, 4 inches), which equals a focal ratio of f/10.

Next month we'll discuss how to match your observing interests to telescope type.



Glossary

Baily's beads appear just before and after totality during a solar eclipse. Fred Espenak

Baily's Beads: first described by English astronomer Francis Baily in 1836; refers to the apparent string of bright beads around the moon's disk just before and after totality during a solar eclipse. This visual treat occurs when sunlight briefly shines through valleys on the moon's edge as it slips in front of the sun.

Cardinal points/directions: the four main horizon points — east, west, north, south — that mark directions.

Celestial equator: the projection of Earth's equatorial plane into space marking the boundary of the northern and southern hemispheres and the zero mark for declination.

Constellation: any of the 88 arbitrary groups of bright stars whose boundaries were set by the International Astronomical Union in 1930.

Ecliptic: the apparent path of the sun across the sky.

Meridian: an imaginary circle that passes through both the north and south poles, as well as the zenith.

Zenith: the point directly overhead when you are outside observing.

Zodiac: the band of constellations through which the ecliptic passes.

Web picks

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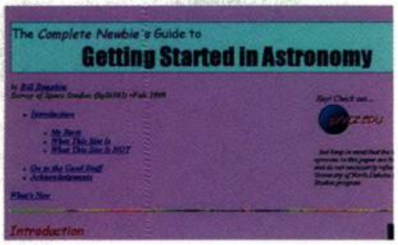
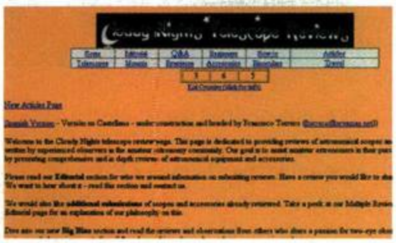


FinderScope.com



FAQ for sci.astro
Frequently Asked Questions in Astronomy
Introduction
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The universe is a bewildering place for anyone new to astronomy. Likewise, beginners searching the Internet for good astronomy websites may find themselves lost in cyberspace. And so Web Wizard Richard Bartlett — who usually writes our Web-weaver Picks column for Star Stuff — compiled the following suggestions to guide newcomers to the most informative sites:

Astronomy magazine's website has its own beginner section at http://www.astronomy.com/Content/static/beginners/default.asp. Here you'll find articles covering the basics, such as equipment, observing tips, and a glossary. An interactive star map allows you to generate views of the night sky for any location on any date and time during the year.

Another one of the best places to go for some friendly advice is Tom Campbell's website at http://www.iolaks.com/softech/astro/astro.htm. These pages contain useful information for the aspiring astronomer and include tutorials on constellations, observing and equipment tips, and advice for first-time astronomers. It's a basic website that helps inspire readers and encourage them to investigate further.

A similar site is Bill Dauphin's Complete Newbie's Guide to Getting Started in Astronomy at http://pw1.netcom.com/~dauphinb/newbie.htm. A self-confessed newbie, Dauphin takes a humorous approach by sharing some of his own experiences. Diary pages detailing his observations and projects are particularly interesting reading.

If you can't wait to start observing, go to FinderScope.com. This well-designed site has some great features. For example, enter your zip code (or latitude and longitude) and the site not only calculates the current data for the sun and moon, but also gives observational data for the planets, stars, constellations, and deep-sky objects. Additionally, it tells you where to look in the sky. Links for weather reports and a star map that can be generated via another site are included. Other pages give advice on observing the sky with the naked eye and with binoculars or a telescope. Visit the site at http://www.finderscope.com.

Once you learn the basics of naked-eye viewing, you may want to progress to the next stage: buying binoculars or a telescope. For impartial equipment reviews, go to the Cloudy Nights Telescope Reviews website at http://www.cloudynights.com. Despite the title, the site reviews binoculars, too. And, an entire section devoted to beginners also contains equipment recommendations.

If, after visiting each of these sites you still have questions, then try T. Joseph W. Lazio's compilation of Frequently Asked Questions at http://sciastro.astronomy.net/ or the Allexperts astronomy page at http://www.allexperts.com/getExpert.asp?Category=1360. Both of these text-heavy websites cover diverse subjects such as astrophysics and extraterrestrial life.

Allexperts.com features a panel of experts ready to answer almost any question you may have about astronomy. A short bio for each expert details his or her specialty and experience. You can read online comments from previous users who have also rated the experts for knowledge, clarity, timeliness, and politeness.

Who knows — someday you may find yourself listed among the experts. — *You can visit Richard Bartlett's website, StarLore, at http://www.starlore.net.*

Trichannel Astrophotography

by Chris Schur

During the '90s, astrophotographers saw an explosion of new fast and fine-grained films, advances in hypersensitizing techniques, and the widespread use of digital imaging to bring out the most details in their astronomical images. We can now combine an array of advantages of different films to produce a virtual emulsion — a superfilm for the new millennium.

Color images are composed of three channels: red, green, and blue. Each channel represents a color in the final image. For example, color film consists of three layers. Each layer isolates a range of wavelengths to generate a channel of the combined image. By combining the three layers, we form the final color image. Once digitized, a photograph of a galaxy, nebula, star cluster, or planet usually consists of three colors labeled R, G, and B.

Many amateur astronomers have digitally scanned their conventional astrophotos and have found ways to improve them using image processing software like Photoshop. Rather than working on RGB files, however, I suggest you try another technique. Another filtering technique is based on the LRGB system, which adds another channel to the three colors — the L stands for luminosity. Developed in 1982, this so-called lab system separates a color image into three different channels. Rather than red, green,

My Favorite Objects/David Higgins, Oklahoma City, Oklahoma

I've always enjoyed tracking down "faint fuzzies" — those objects at the edge of the visible universe for amateur astronomers. The allure comes from the satisfaction of knowing that I've seen objects that most people on Earth don't know about. Learning about the different types of objects I observe and how they fit into the universe is, for me, one of the most enlightening and humbling experiences I've ever had.

The Andromeda Galaxy and M33

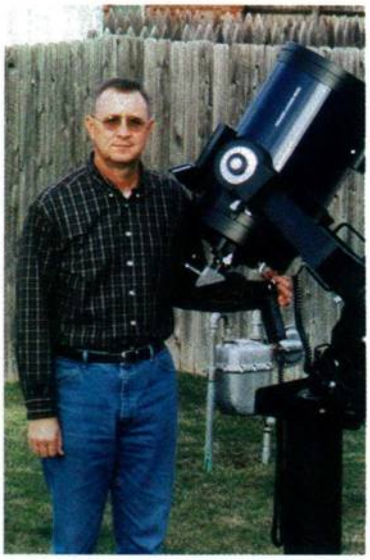
My favoite object is M31, Andromeda's giant spiral. With the advent of CCD technology, the amount of detail that we can go after in M31 is phenomenal. Another familiar object that has benefited from the CCD revolution is M33, the Pinwheel Galaxy in Triangulum. Armed with a marked-up CCD image, you can visually go after globular clusters, star clouds, HII regions, and stellar associations within these galaxies. To see components of another galaxy and relate them to the familar clusters and clouds in the Milky Way seems very exciting to me. To see a distant speck of a globular cluster and know that it is every bit as impressive as Omega Centauri or the Hercules Cluster is simply awe-inspiring.

Omega Centauri and the Hercules Cluster

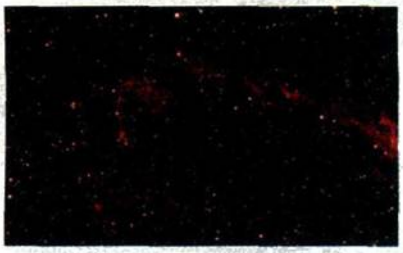
If you want to look at deep-sky objects and get a feeling of 3-D observing, look no farther than these two great clusters. In a large backyard scope, Omega Centauri seems to float in the eyepiece with countless thousands of stars forming a globe. The thought of hundreds of thousands of stars packed together, jostling and orbiting, with merely 2 light-years between them, accentuates the sight. M13 in Hercules seems to look like an angry crab whose body consists of glowing suns.

The Orion Nebula

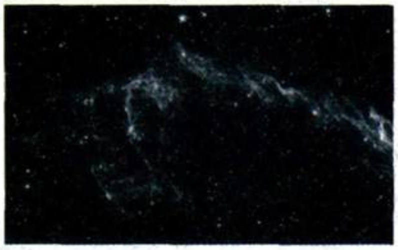
My list wouldn't be complete without the Orion Nebula, M42. It was the first deep-sky object I looked at, as a child, and it still amazes me with every view. In a large scope, this star-making factory presents a tremendous amount of detail and also strongly gives viewers a 3-D appearance. Some of the swirling clouds of gas and dust remind me of the dark springtime thunderstorms we experience in Oklahoma City. And the knowledge of what's going on within this nebula is humbling — it gives you an awful dose of perspective. The chance to see other M42s — in M31 and M33 — is simply, as my son says, "sweet."



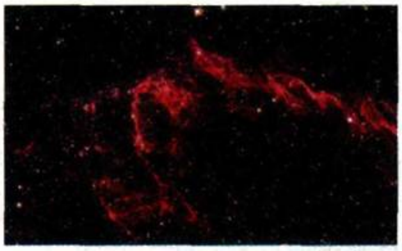
David Higgins



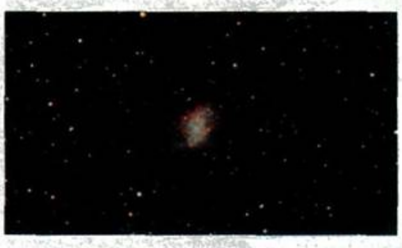
A Veil Nebula shot made on Kodak PJ 400 film, the first tricolor step. Chris Schur



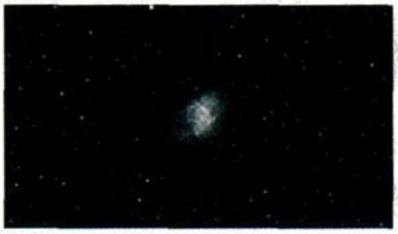
Contrast comes from an identical shot on hypered Tech Pan film. Chris Schur



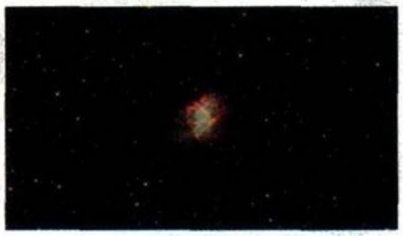
The resulting combination boosts color and contrast, yielding a "pop." Chris Schur



The Crab Nebula shot on Kodak Pro 400 PPF shows its tendrils. Chris Schur



A booster shot from a black-and-white Crab comes on Tech Pan. Chris Schur



The resulting final image brings out the Crab details at their best. Chris Schur

and blue, the lab system separates images into a brightness channel and "a" and "b" channels, which represent the equivalent of x and y coordinates on a graph of the image's color distribution.

Using the lab system allows you to create images of the same object made with different films into a single result. Creating this virtual film permits capturing the subtle colors of a nebula or galaxy accurately while boosting its contrast and nebular detail substantially. I recommend doing this by shooting the luminosity frame on Kodak's Tech Pan film, hypersensitized for maximum effect. The detail, color, and sharpness of the resulting images are astounding.

Under the Night Sky

The first step is to capture a matched pair of images — one color and one black and white — with your telescope and camera. Exposure times must be chosen so that both record roughly even amounts of nebulosity. This is typically 30 to 60 minutes at f/5, or 15 to 30 minutes with faster telephoto systems. Normally the images can be taken on different nights, as long as you take careful notes as to the alignment of the field view and the guide stars chosen for each shot. The key is to be able to align the images as precisely as possible for the maximum overlap.

The best subjects are those that are not too bright. Objects such as the Orion Nebula or bright stars near nebulosity such as Zeta Orionis make poor targets. Good targets include large, low-surface-brightness galaxies, emission nebulae, most open clusters, and comets.

Once you have a pair of images, develop the film, mount them in slide holders, and carefully label them. Now they can be scanned. I use the Polaroid Sprintscan scanner and can recommend it enthusiastically. You could also have a Photo CD made of the entire roll at the nearest camera store.

Films for Trichannel Photography

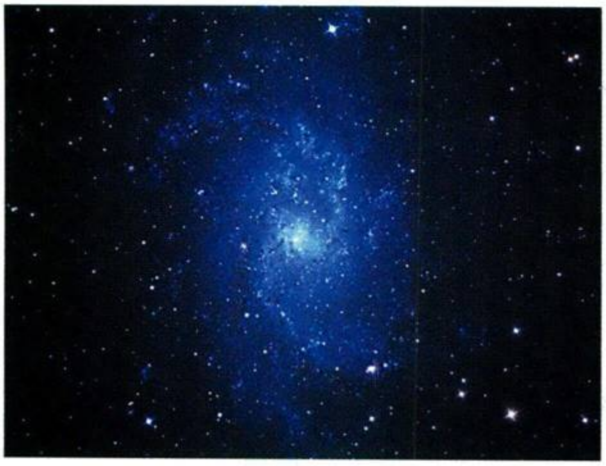
Selecting the correct film is crucial. Hypered Kodak Tech Pan is the top choice for the black-and-white exposure to be used for the luminosity channel. It has extremely fine grain, a high level of contrast and tonal resolution, and is easy to develop.

Which color film you use depends on the type of object to be photographed. For galaxies and star clusters, a blue-sensitive film like Kodak Gold 400 or Fuji NPH 400 works well. For red objects like emission nebulae, Kodak PJ400 and Kodak E200 professional slide film work well. Although any type of color film can be used to obtain the "a" and "b" color channel information, the best choices are those that have fine grain. Avoid films that are ISO 1000 or faster, as they will be too grainy.

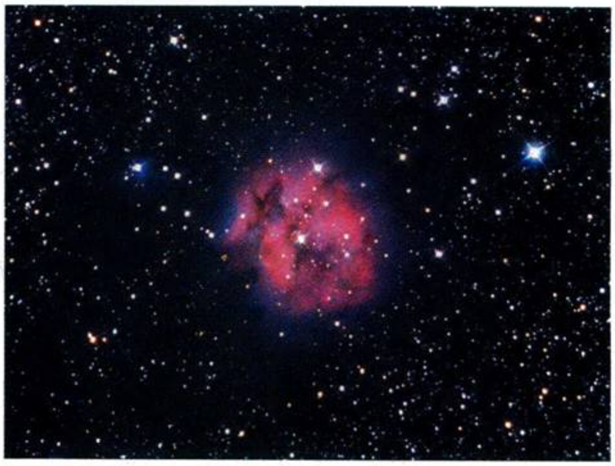
Development and Scanning

Although many astrophotographers use commercial developers, you can probably do a better job by developing film at home. For color developing I recommend the Bessler CN2 kit, commonly available at photo stores. The process consists of three steps that take only a few minutes at 100° F. The resulting negatives will be ready for printing, scanning, or archival storage. For black-and-white development, I use D19 developer, stop bath, and fixer all at 68° F to obtain high-contrast, high-resolution images of faint objects.

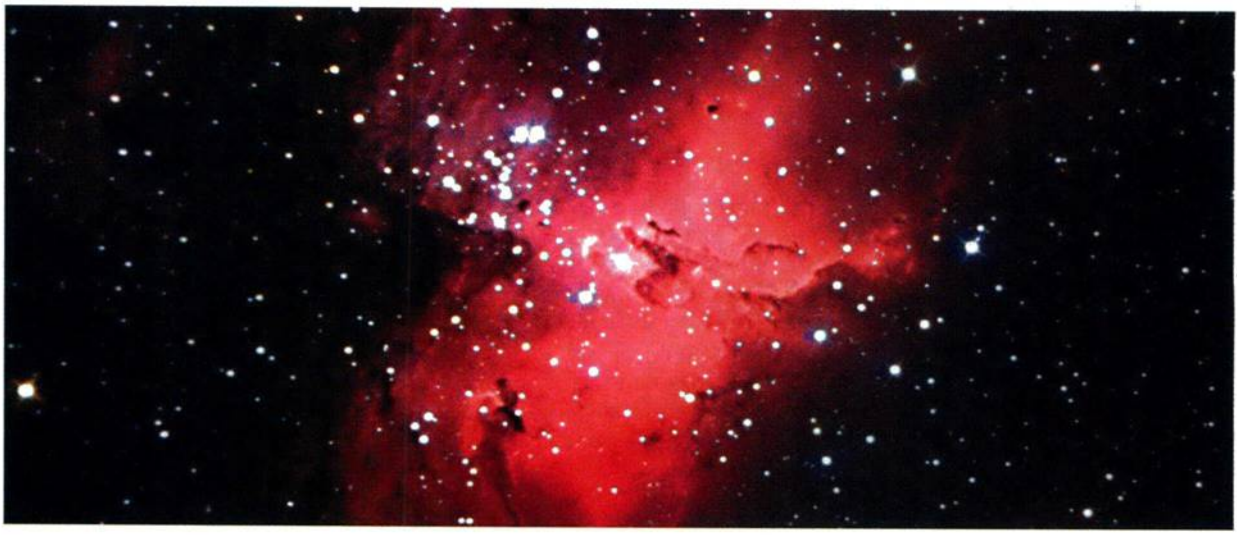
Once you have the transparencies or negatives, you need to scan them to create high-resolution digital versions. Many inexpensive scanners are now available, but most are not sufficiently good for scanning astronomical objects. Units that operate well include the Polaroid Sprintscan 4000 ($500–$700, 4,000 dpi, 36 bit) and the Nikon Super Coolscan IV ED ($800, 2,900 dpi, 48 bit). Other scanners can also provide high-resolution results; these two companies and units are recommended.



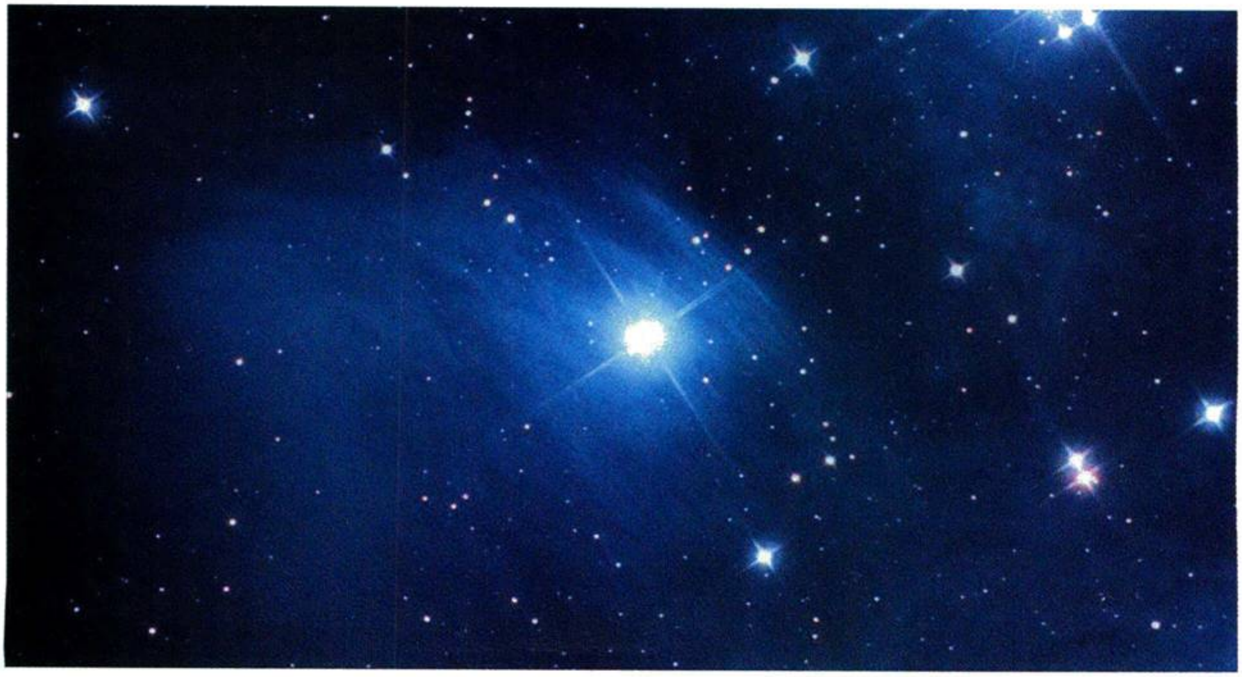
The Pinwheel Galaxy, M33: composite of two 45-minute exposures on Pro 400 PPF and one 60-minute Tech Pan. Chris Schur



The Cocoon Nebula, IC 5146: composite of two 45-minute exposures on Pro 400 PPF and one 60-minute Tech Pan. Chris Schur



The Eagle Nebula, M16: composite of two 45-minute exposures on Pro 400 PPF and one 60-minute Tech Pan. Chris Schur



The Pleiades, M45: composite of one 45-minute exposure on Pro 400 PPF and one 60-minute Tech Pan. Chris Schur

For best results, astronomical images should be scanned not only at the highest resolution, but also the highest bit depth. Scan images at 36 bits for maximum dynamic range. After scanning, you may want to save images in 36-bit TIFF format, which is the standard used by most software programs such as Adobe Photoshop and Paint Shop Pro. These programs, along with Corel PhotoPaint, are probably the best image workshop packages on the market. Additionally, Digital Light and Color provides a piece of software called Picture Window Pro that is needed to register the images before reassembling them.

Creating lab images takes three steps. First, work on the black-and-white image to be used for the lab channel. In Photoshop, remove any scratches or dust, and adjust its background to a medium dark gray. Also increase the color saturation anywhere from 20% to 50%. The lab composite process will create a loss of color and this will help to compensate.

Next, bring in the color image, which must be registered so that when the channels are combined stars will line up as round, crisp images. In Photoshop or Paint Shop Pro, layer one of the images on top of the other with precise alignment and flatten the result by applying 100% opacity in the upper image. The easiest way to do this is with Picture Window Pro, which allows stacking images by registering stars across the frame. Normally I stack the color image on top of the black-and-white and the resulting color image is saved with a new name. This image will be used for the "a" and "b" channels in the composite.

The final step is to make the lab composites. First open the black-and-white image in Photoshop. Select it and cut so it is placed onto the clipboard. Next, open the registered color image and convert it into lab color. Select "lab color" from the pulldown "mode" menu. This will change the format of the image from RGB to lab. Now open the channels palette, and click on the "L" channel. The image will transform into a low-contrast black-and-white image — the luminosity portion of the color photo. Next, paste the earlier Tech Pan image onto the luminosity image, replacing it. Then reconvert the image to RGB and carefully make all the final adjustments in color balance and density.

You'll immediately see impressive results. Dim nebulae that were filled with grain and lacking in detail now burst with rich detail, high contrast, and high resolution. Bok globules and dark nebulae seem to explode from the image. Star clusters are glittering jewels with star images that are a fraction the size of the originals. Galaxies yield rich yellow cores and outer spiral arms with detail that rivals observatory prints. For more details on this technique and examples of my photography, see http://www.psiaz.com/Schur/astro/. ■

Chris Schur is an avid astrophotographer living in Payson, Arizona. He has contributed frequently to Astronomy *in the past both in words and pictures.*

Challenging Comets/ Mar. 2002

In any month, usually several comets glow brightly enough to become visible to those with large telescopes. Here are coordinates and magnitudes:

7P/Pons-Winnecke

Mar. 1	16h55.5m, 3°48', 13.3
Mar. 11	17h26.0m, 3°00', 12.8
Mar. 21	17h57.9m, 2°04', 12.3
Mar. 31	18h31.4m, 0°54', 11.9

C/2000 SV74 (LINEAR)

Mar. 1	23h31.0m, 57°46', 14.0
Mar. 11	23h41.4m, 59°26', 14.0
Mar. 21	23h53.2m, 61°24', 14.0
Mar. 31	0h06.4m, 63°39', 14.0

19P/Borrelly

Mar. 1	12h31.9m, 53°03', 14.1
Mar. 11	12h16.1m, 53°23', 14.5
Mar. 21	12h00.6m, 52°51', 15.0
Mar. 31	11h47.4m, 51°33', 15.4

C/2001 W2 (BATTERS)

Mar. 1	20h50.4m, –36°03', 14.4
Mar. 11	21h05.8m, –40°56', 14.6
Mar. 21	21h22.8m, –46°16', 14.8
Mar. 31	21h42.1m, –52°08', 15.0

C/2001 N2 (LINEAR)

Mar. 1	20h32.8m, 14°15', 15.5
Mar. 11	20h34.5m, 14°44', 15.4
Mar. 21	20h35.2m, 15°23', 15.2
Mar. 31	20h34.3m, 16°11', 15.0

C/2001 Q2 (Petriew)

Mar. 1	9h38.8m, –7°39', 15.5
Mar. 11	9h30.8m, –5°30', 15.8
Mar. 21	9h25.9m, –3°31', 16.1
Mar. 31	9h24.0m, –1°49', 16.5

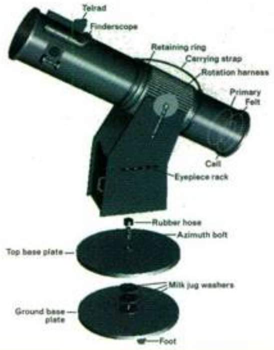
29P/Schwassmann-Wachmann 1

Mar. 1	20h31.4m, –20°53', 15.8
Mar. 11	20h38.7m, –20°22', 15.8
Mar. 21	20h45.6m, –19°52', 15.7
Mar. 31	20h51.7m, –19°24', 15.7

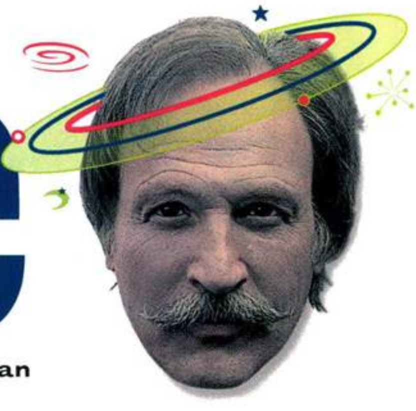
Telescope Tips

Adam's Dob

My son Adam jumped into astronomy in January 2000, buying an 8-inch Dobsonian. We found it much more useful by adding a Telrad finder, a carrying strap, bumpers and reinforcing braces, and an eyepiece rack. A few do-it-yourself additions to an off-the-shelf scope can greatly increase years of observing enjoyment. — *Jerry Chern*



strange Universe



by Bob Berman

Struck by a Meteorite

Nobody knows why so few meteorites are now colliding with Earth. Only a quirk in the laws of chance can explain why all the major meteor showers concentrate in a single 20-week span. During shooting star fireworks that annually peak around January 3, August 12, October 21, November 18, and December 13, between 40 and 30,000 visible bits of interplanetary debris slam into us every hour. But not now. For seven straight months, little more than sporadic pellets pepper the heavens.

So if your personal paranoia extends all the way into space, and your HMO doesn't cover you for meteorite assault, you'd think you could relax during winter and spring. But no such luck.

History tells us that whenever a person, home, or property has suffered a "Close Encounter of the Clobbering Kind," it's happened during non-shower periods like this month. When you think about it, that makes sense. Except for December 13's Geminids, every major shower is composed of skimpy apple-seed-sized debris from comets, lightweight material that typically burns to oblivion during its collision with our atmosphere. Only a dusty trail lingers like a Cheshire Cat's smile after the intruder has gone to meteor heaven.

Sporadics, however, can be made of anything and come from anywhere. They can be sturdy asteroid fragments or even bits of the moon or Mars. Many are half iron, and depending on their speed and initial size, some make it all the way to the ground.

Cooled by the thick lower atmosphere, meteors no longer incandesce as they approach the surface and are barely warm when they land as meteorites, having dramatically slowed from their original fierce speed of 12 to 45 miles per second down to anywhere from 1/20 to one mile per second. But that's still fast enough to cause trouble.

Virtually all produce some damage, even if they don't remotely compare to monsters like the Permian colossus that nearly destroyed our planet's biosphere 250 million years ago. Or the famous K-T event 185 million years later, when a six-mile-wide asteroid erased the dinosaurs and paved the way for us mammals to begin our spectacular evolutionary ascent toward rats and sitcoms. This past November, astronomers using new Sloan Digital Sky Survey data put the odds of a catastrophic, civilization-destroying impact during the next century at one in 5,000. But lesser violence has been far more frequent, chronicled by craters like the one near Barringer, Arizona, created 25,000 years ago.

Experts calculate that each of us is six times more likely to die of a meteorite impact than in an airliner crash. The reason: Even meteorites a few hundred feet wide wreak havoc in a vast region, but extending one's customary amount of jetliner flying for centuries would yield only a small statistical chance of injury — if you could somehow survive all that airline food.

Nor has the violence been limited to ancient history. Many nonagenarians were alive on June 30, 1908, when an 8,000-square-mile zone in Siberia was flattened by an air-bursting meteor. Assuming one of those arrives every century or two, the only good news is that most of our planet's area is oceanic or uninhabited; each time, the odds are in our favor. In between, we experience the bam-bam-bam of smaller strikes that forever fall among us as if hurled by a relentless baseball-throwing machine. A building in North America is struck every 15 months, on average.

Sounds ominous. But usually meteors bring glad tidings of temporary celebrity and even wealth. And — so far — never grievous injury, unless one includes the Franciscan monk in Milan who died mysteriously in the 17th century after being struck in the leg by a plum-sized stone "falling from the sky," which severed an artery. While possibly true, the account can't be confirmed, nor can newspaper reports of a calf being struck in Ohio in 1860 or a dog killed in Egypt in 1911.

In our era, the surest instance is seen in a 1954 *Life* magazine photo-story about a woman in Sylacauga, Alabama. Mrs. E. Hewlett Hodges had been lounging on her couch when a meteorite smashed through the roof, bounced off her radio, and ricocheted onto her upper leg. The resulting bruises remain the only confirmed meteorite injury.

Note: A sky-streak is always a meteor and a stone found on the ground is always a meteorite. A meteor changes into a meteorite the instant it strikes our planet.

Twenty-year-old Michelle Knapp of Peekskill, New York, didn't believe it herself when she heard a loud crunch in her driveway on October 9, 1992. Finding the back half of her Chevy grotesquely destroyed, she attributed the damage to some ultra-powerful vandal. She couldn't know that people up and down the East Coast had just seen and videotaped fiery northward-whizzing meteor fragments, and that her car was the victim of the only piece known to have landed.

Of course, it didn't appear lucky at first: the damage lay decisively outside the manufacturer's warranty. Even when investigators found the eight-pound meteorite under the car's twisted trunk, the event seemed a bizarre fable where destiny had swapped her car for an ugly stone. The happy ending came when a collector came around and offered her $69,000 for the meteorite and the totaled 10-year-old-Malibu.

The situation also didn't seem fortunate for Bob and Wanda Donohue of Wethersfield, Connecticut, on the evening of November 30, 1982. They'd been watching TV ("M*A*S*H") when the next room suddenly exploded into chaos. Rushing through the door, they found smoke and dust filling the air, furniture knocked over and a strange hole in the ceiling. When emergency personnel arrived, a fireman found a six-pound rock under the table where it had settled after a few floor-to-ceiling bounces chronicled by scuff marks in the carpet. The Donuhues donated the valuable specimen to a New Haven museum, where it remains on exhibit.

They weren't quite as amazed as residents of any other town might have been. In fact, they were almost used to it. Eleven years earlier, in April 1971, the previous meteor known to crash into the roof of a U.S. home had struck barely more than a mile from the Donohues in that same town of Wethersfield. The freak coincidences are explicable only by their proximity to Hartford and that region's high concentration of insurance actuaries, experts who know better than anyone else that the same town cannot be hit consecutively by shooting stars.

And it never stops. Several stray meteors will pass within a few dozen miles of you during the next 60 minutes, with twice as many during A.M. than P.M. hours. You've got as good a chance as anyone else to have an asteroid plop onto your kitchen table — bearing the gifts of damage, wealth, and proof that we do indeed live in a strange universe.

Bob Berman is a regular contributer to Astronomy magazine, *providing both feature stories and "Strange Universe." He also writes books, such as* Cosmic Adventure, *perfect for gift giving.*

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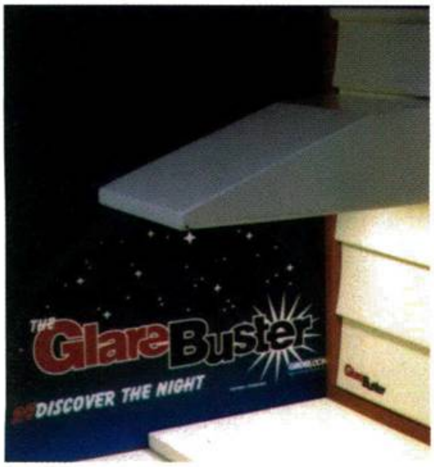

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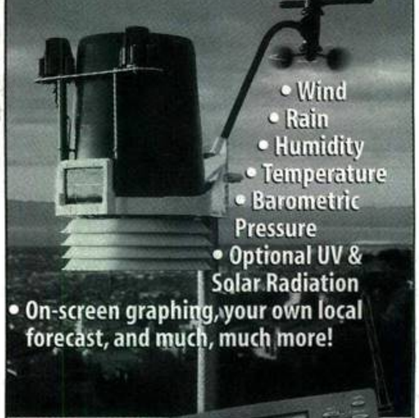

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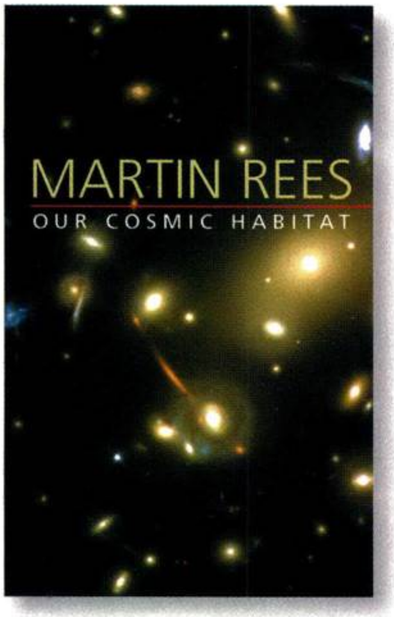
BOOKS

Our Cosmic Habitat

Martin Rees, 205 pages, Princeton University Press, Princeton, New Jersey, 2001; ISBN 0-691-08926-4; hardcover, $22.50.

Sir Martin Rees is Great Britain's Astronomer Royal both by title and through his vast store of astrophysical knowledge. Rees often gives professional and public talks on astrophysics and cosmology, which are always clear and erudite. *Our Cosmic Habitat* is based on a series of lectures Rees gave while visiting Princeton University and reading it is very much like hearing him speak.



This book provides a review and explication of our current view of the universe in context of an overarching question posed as "Why is our universe biophilic, so hospitable to life?" This question, when rephrased as "How can we explain that the universe seems to be tailored for life?," is important scientifically, philosophically and religiously. Others have addressed this question in many ways, including the Anthropic Principle, Creationism, and other speculations.

At this stage the answer is not yet clear. Possible answers include happenstance, providence, or coincidence. According to Rees, the answer depends on whether or not we reside in the only possible universe or in one of many potential or actual universes, or "multiverses." These are the issues of the big question; however, Rees provides a thorough background and explanation before coming back to it.

Rees begins with a prologue that outlines the topics and issues of the book and sets the reader up for its development. He starts with an exploration of our solar system and the issue of stars and planets, including the new field of detecting and observing extrasolar planets. The first section deals with how science gets from the Big Bang to biospheres. Rees then discusses the possibilities of life and intelligent life on other planets. This is followed by a clear discussion of what we know about the structure of the universe and its evolution.

The second section, "The Beginning and the End," moves a step beyond and focuses on the new results of a universe whose expansion is apparently now accelerating and speculates both about the implications for our long-term future and about the beginning of the universe.

The third and final section, "Fundamentals and Conjecture," moves further into speculation about how the cosmos and microworld are related — how one would understand physical laws that are fundamental and without potential alternatives, as well as those physical laws (which Rees calls bylaws) that are partially accidental in the sense of being stochastically determined at the beginning — but fixed against future change. These bylaws would be different or slightly different for each sub-universe in a larger multiverse. This last point is key; unlike in the case of Darwinian evolution of life on Earth, the physical laws are set immutable in that life must conform to them but does not react back on them and alter them.

Our Cosmic Habitat is very easy to read and follow and provides a coherent structure in which knowledge of our cosmos is fitted and future information will readily be included.— *Experimental astrophysicist George F. Smoot is an active researcher in observational astrophysics and cosmology at the Lawrence Berkeley National Laboratory and the University of California at Berkeley.*

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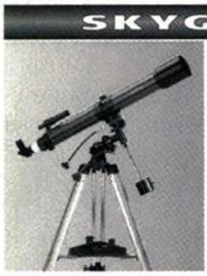

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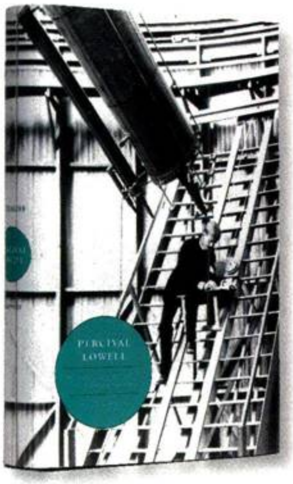
Percival Lowell: The Culture and Science of a Boston Brahmin

David Strauss, 333 pages, Harvard University Press, Cambridge, Massachusetts, 2001; ISBN 0-674-00291-1; hardcover, $45.



If you want to understand the motivations and cultural puzzle that gave Percival Lowell his multidisciplinary personality, then read this book. Lowell's complex pursuit of life, literature, and science are laid out in this intriguing road map of his life.

The book is essentially a mosaic of information that paints a detailed picture of Lowell. Author and historian David Strauss leads readers through the tapestry of Lowell's life in a thorough but repetitive style that is at times difficult to read.

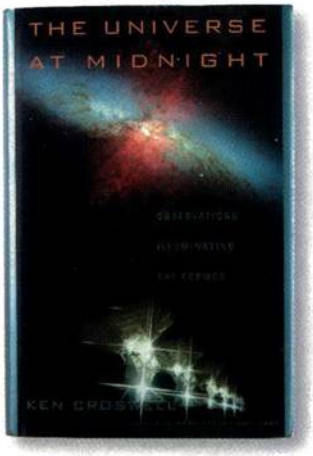
At first I was annoyed with the repetitive nature of the story: the private Lowell, Lowell as Spencerian, and Lowell as astronomer. Each time, Strauss paints a new image of Lowell as it pertained to that facet of his life and career. It became apparent that in order to understand the complete picture of Lowell, I had to accept the redundancies.

Lowell was a unique individual for his time, a true Renaissance man. He believed that a person could not only become accomplished in various subjects, but could also have the discipline to be recognized as an authority in multiple fields. Lowell lived out those beliefs: He became a world traveler, cultural historian, poet, writer, philosopher, and a man of science — and was recognized for his accomplishments in each of those areas. This multifaceted background shaped his views of the cosmos.

Lowell challenged the traditionalists in astronomy by focusing on the evolution of our solar system during a time when mainstream astronomy was looking deeper into the cosmos. Even though Lowell could have become a part of the traditional astronomy community by developing his observatory in partnership with a major university (and follow its accepted path in research), he decided against this course. Instead, he developed a private observatory that allowed him to pursue his interest in the evolution of the solar system in general, and the details of Mars in particular.

While Lowell's insightful vision into the formation of the universe and solar system put him decades ahead of other astronomers, his literary and poetic background led to his supposition of advanced life on Mars. His vision gave rise to both the observatory and financial support that was necessary for the discovery of Pluto.

To understand the man, you need to understand his background. To understand his background, Strauss invested a tremendous amount of research, leaving you with a clear picture of the man. *Percival Lowell* leads to a deep understanding of Lowell and how his experiences shaped these critical decisions. *— Gil Clark not only works for JPL and manages the Table Mountain Observatory and Facilities for the Earth and Space Sciences Division, but also is president of the Telescopes In Education (TIE) Foundation.*



The Universe at Midnight: Observations Illuminating the Cosmos

Ken Croswell, 325 pages, Free Press, New York, 2001; ISBN 0-684-85931-9; hardcover, $27.

After reading Ken Croswell's *The Universe at Midnight*, you'll marvel that the science of cosmology has advanced one iota by the dawn of the 21st century. Croswell's detailed account of huge egos and warring points of view illustrates the personal struggles that underlie all great discoveries. Perhaps the combatants in this tale need boxing gloves to settle their flaming differences. But the finale may not yet be fixed.

At the heart of Croswell's book is one huge question: What is the fate of the universe? Will it eventually contract to its singular starting point, reach a steady state of balance or continue expanding forever?

The answer, according to the latest agonized consensus, is the latter. The expansion first observed by Edwin Hubble will continue to accelerate until all the billions of observable galaxies outside the local supercluster held together by gravity will disappear from our point of view.

Croswell, a Harvard-trained astronomer, traces the often vicious battles among modern professional astronomers to determine the so-called Hubble Constant, which, as it turns out, is anything but constant. Knowing the rate of expansion would solve the riddle of our final fate. As the book closes, we think we know the answer, but the author is wise enough to add this postscript quote from Edward Harrison: "The standard model of the universe at the end of the 19th century was unlike the standard model at the end of the 20th century in almost every respect."

This prompts the question: Is it possible that the standard model of the universe at the end of the 21st century will be totally unlike that at the end of the 20th century? The Victorians were confident that they were close to the truth. What are we to make of the fact that today there is a similar attitude?

Two of the most believable characters emerging from Croswell's book are unlikely names: Edgar Allan Poe and Mark Twain. Best known for dark tales like "The Fall of the House of Usher" and "The Raven," Poe actually postulated the Big Bang and the current debate long before the professionals by deducing that all matter attracts all other matter. "Does not so evident a brotherhood among the atoms point to a common parentage?" Poe wrote. "Is it not because the atoms were, at some remote epoch of time, even more than together? Is it not because originally, and therefore normally, they were one? . . . That they struggle back to this absolutely, this irrelatively, this unconditionally one?" That's not bad thinking from a guy who died in 1849 at age 40.

Much of Croswell's book centers on the raging personal disputes among modern-day astronomers trying to determine the Hubble Constant. Just as the reader grows weary with all this squabbling, Croswell tosses in a quote often attributed to Mark Twain: "The researches of many commentators have already thrown much darkness on this subject, and it is probable that, if they continue, we shall soon know nothing at all about it." Twain's astute observation on page 172 comes just in time to rescue this book from a severe case of dreariness.

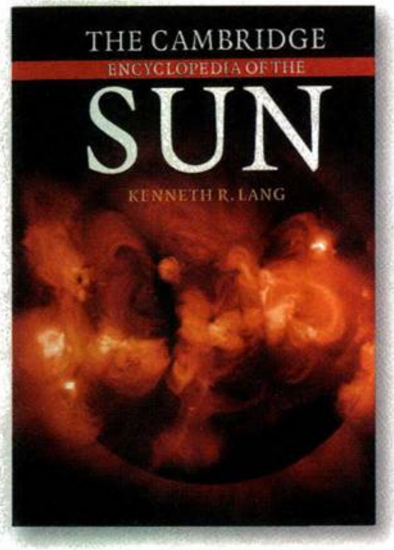
The Universe at Midnight perks up considerably toward the end. If the universe is destined to expand forever, with nothing much to look at, what will happen to the science of astronomy? And what will humans do six billion years down the road, when the sun bloats into a red giant, engulfing Mercury, Venus, and possibly Earth? Croswell proposes a unique solution.

Without giving away his surprise ending, let's just say the answer involves hauling our own planet around in the back of a pickup truck to find a new home. — *Nick Nichols is the retired news media relations manager at the Idaho National Engineering and Environmental Laboratory in Idaho Falls. His hobby is amateur astronomy.*

The Cambridge Encyclopedia of the Sun

Kenneth R. Lang, 256 pages, Cambridge University Press, New York, 2001; ISBN 0-521-78093-4; hardcover, $49.95.

"Coffee table or classroom?" Large, glossy science books with lots of pictures tend either to gloss over technical details, or be too dry to be useful outside of a lecture course. Ken Lang's new opus, *The Cambridge Encyclopedia of the Sun*, happily breaks the rule. Its 256 pages glow with hundreds of brilliant, glossy illustrations that capture both the scientific essence and the wonder of modern solar research.



The sun is the only star close enough to Earth to image clearly and is both wondrous and complex.

Recent advances have revealed its large and mysterious internal structures. The solar corona is brighter than the full moon and larger than the constellation Orion. Solar activity generates interplanetary shock waves and geomagnetic storms that cause the beautiful northern lights, disrupt our technology, threaten astronauts, and possibly affect Earth's climate. The *Encyclopedia* provides an excellent, up-to-date overview of each fascinating aspect of solar study.

Organized logically rather than alphabetically, the *Encyclopedia* tours the field with a broad overview of solar physics, followed by each of the major subfields. Lang takes us from a stellar context, through the physics of fusion and the solar interior, to the important and bizarre surface magnetic field and its effect on the solar corona and solar flares. Finally, we cross the void of interplanetary space itself to discover how the solar wind and activity affects humanity. He finishes the book with an overview of the exciting instruments and observations that are currently revolutionizing solar physics.

An encyclopedia should be well-indexed and Lang's book is no exception. The glossary and index together comprise more than 50 pages and are complete. Handy fact tables reference the important empirical numbers (such as the solar mass, luminosity, and size), physical constants, and units often needed by students and scientists.

Two appendices offer further references into the printed literature and on the Internet. The web addresses are worth special notice because most modern solar instruments have "wide open" data policies, making it possible for an interested amateur to retrieve and use current solar data from several NASA satellites — as well as ground-based observatories — via the Internet links provided.

Despite the logical ordering, it is not necessary to read the *Encyclopedia* straight through. The structure is modular enough and interesting enough to encourage casual flipping from section to section. It's hard to open a page and not find a fascinating or beautiful picture, engrossing prose, and punchy, cogent tables of facts.

Scientific results are current, some taken directly from technical journals less than a year old. In particular, the discussions of solar wind, sonic holography of the sun's far side, and origins of the aurora reflect very recent discoveries; other fascinating, up-to-the-minute results pepper each section.

Well conceived and brilliantly executed, Lang's latest work has a flair and beauty that make it an excellent coffee-table or gift book. But the attention to detail and clear explanations also make it a well-rounded coursebook for professors teaching solar physics. I like to keep it nearby during classes or when I need a quick fact. The technical detail makes *The Cambridge Encyclopedia of the Sun* a handy reference.

Buy this book. You'll be glad you did. — *Craig DeForest is a solar researcher at the Southwest Research Institute, Boulder, Colorado.*

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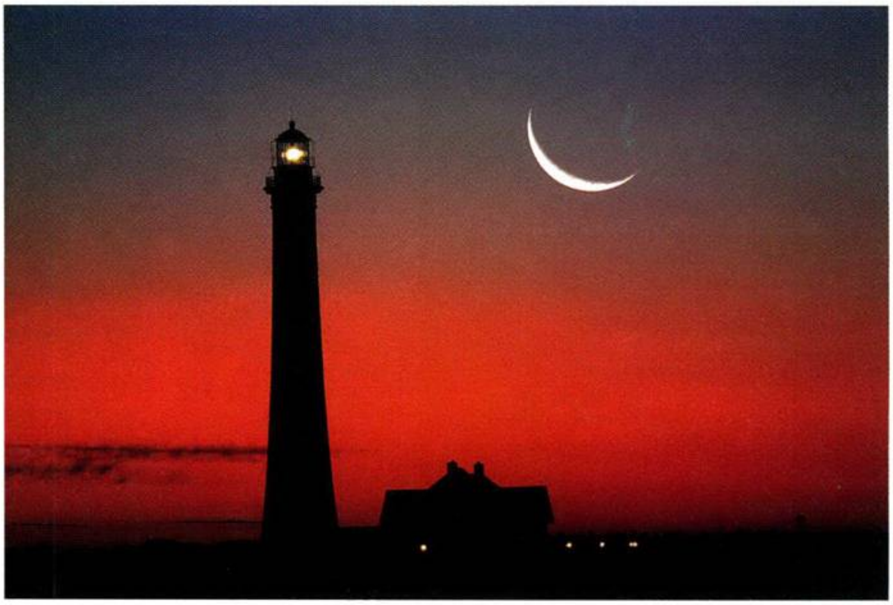
LOOKING AHEAD

MARCH



Larry Landolfi

For star parties held around mid-March, the young moon will be a popular attraction.

Wirruna is not only the Aboriginal word for "sunset," it is also the appropriate setting for Australia's largest amateur astronomical event. Located near Ilford, three hours northwest of Sydney, the South Pacific Star Party (March 15–17) provides attendees with the opportunity to meet other amateur and professional astronomers, as well as observe under dark skies with superb observing conditions using all types and sizes of telescopes. Following 2001's successful event, this year's SPSP will offer informative and entertaining daytime workshops and lectures followed by spectacular observing at night under dark skies.

Wirruna is also a paradise for nature lovers. When not peering through an eyepiece, take time to enjoy the local wildlife, including wombats, kangaroos, and numerous colorful birds. For more information, contact the Astronomical Society of New South Wales via e-mail at Secretary @asnsw.com or visit their website at http://www.asnsw.com.

MARCH 2

Tri-Star 2002

Guilford Technical Community College, Jamestown, North Carolina, in association with the Greensboro Astronomy Club, will be hosting Tri-Star 2002 in the auditorium of the Applied Technology building on the campus of GTCC. This event will feature a program of guest speakers, displays by vendors, and an evening observing session using the Cline Observatory's16-inch telescope located on campus. Admission is free and the event is open to the general public. For more information, contact Tom English at (336) 334–4822, ext. 2620; e-mail, englisht@gtcc.cc.nc.us.

MARCH 3

Wagman Winterfest

Nicholas E. Wagman Observatory, near Russellton, Pennsylvania. Sponsored by Amateur Astronomers Association of Pittsburgh. Admission is free. For more information, contact AAAP's Wagman Observatory at (724) 224–2510 or Winterfest Director Pete Zapadka at (412) 487–9363; e-mail, pzapadka@home.com; website, http://www.trfn.clpgh.org/aaap/pzapadka/wfest.html.

MARCH 4–8

Lunar and Planetary Science Conference

NASA Johnson Space Center, Houston, Texas. Sponsored by the Lunar and Planetary Institute and the NASA Johnson Space Center. For more information, contact Cheryl Perry, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058–1113; (281) 486–2123; e-mail, perry@lpi.usra.edu.

MARCH 8–17

Astronomy's Northern Lights Tour

Join *Astronomy* on this watch for the magical northern lights in the heart of Alaska. The experience begins in Chena Hot Springs, 60 miles from Fairbanks. Solar activity is expected to be high in March 2002. The adventure continues with five nights in Fairbanks with a variety of activities. The breathtaking scenery is guaranteed to put you on sensory overload. For more information, contact Specialty Tours at (800) 677–9412 or (727) 796–7555; e-mail,markh@alspecialtytours.com; website, http://www.a1specialtytours.com.

MARCH 12

Free Planetarium Show

Gary E. Sampson Planetarium, Wauwatosa West High School, Wauwatosa, Wisconsin. 7 P.M. Seating is limited; for reservations call (414) 773–3007. The free, one-hour shows will take place on the second Tuesday of every month throughout the school year. For more information, contact Mary Pat Pfeil at (414) 773–1022.

MARCH 14–17

Highland's Stargaze - A Trip to Venus

Private campgrounds, Venus, Florida. Let the Astronomical Society of the Palm Beaches be your host on the first ever Trip to Venus. The Highlands Stargaze will be held at a new private location. Observe under dark venusian skies with all the earthly conveniences less than ten minutes away. Camping available on the huge observing field. For more information, contact Kye Ewing at (561) 683–5870; e-mail, astrokye@gate.net; website,http://www.triptovenus.com.

MARCH 14–17

Kisatchie Star Party

Kisatchie National Forest, Louisiana. Sponsored by the Baton Rouge Astronomical Society. This year's theme will be "Back to Basics" with lectures and workshops dedicated to some basic astronomical topics. Admission is $10 for adults and free for those under 18. For more information, contact Don Weinell, e-mail, weinell @eatel.net;website, http://www.eatel.net/~weinell/.

MARCH 21

Ancient Astronomies, Ancient Worlds

Universe Theater, Adler Planetarium and Astronomy Museum, Chicago, Illinois. 7 P.M. Clive Ruggles of the University of Leicester, England, will explore the variety of ways humans have come to terms with what they perceive in the skies, using examples from the Stone Age to the present. Key questions and issues facing modern-day archaeoastronomy and ethnoastronomy will be addressed. Arrive early at 6 P.M. for a guided tour. For more information, contact (312) 922–STAR; website, http://www.adler-planetarium.org.

APRIL 6

StarConn 2002

Wesleyan University, Middletown, Connecticut. The Astronomical Society of Greater Hartford will sponsor StarConn 2002, its 16th annual convention. The one-day event is a symposium of many famous lecturers in various fields of astronomy. For more information, visit their website, www.asgh.org.

APRIL 20

Dallas Astronomy Day

Richland College, Dallas, Texas. Events begin at 11 A.M. and include hourly planetarium shows, various guest lectures, mirror grinding and telescope making presentations, multimedia exhibits, hands-on activities for kids, and telescope viewing till 11 P.M. For more information contact Dan Doyle, P.O. Box 703247, Dallas, Texas 75370–3247; (972) 394-5694; e-mail, starmandan@hotmail.com; website, http://www.texasastro.org. ■

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or jmcgovern @astronomy.com. Look for additional events at http://www.astronomy.com.

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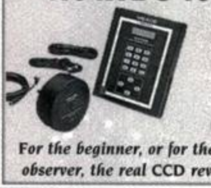

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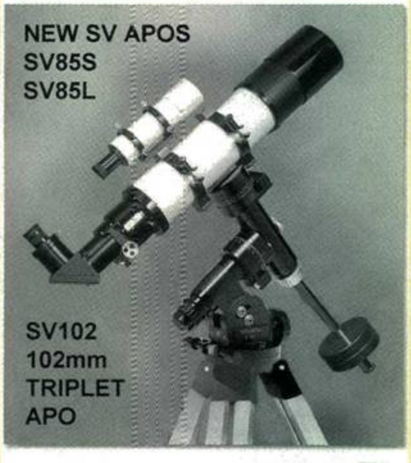

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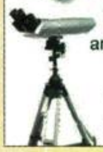

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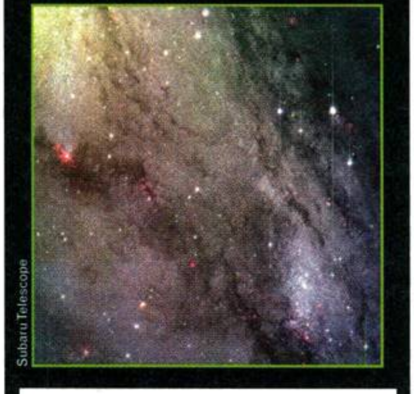

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LEONID METEOR SHOWER

Natural Fireworks

Leonid over Nova Scotia

BARRY BURGESS

(35mm lens at f/2, Fuji Superia 400 film, 6-minute exposure)

Leonid over Joshua Tree National Park, California

WALLY PACHOLKA

(50mm lens at f/1.2, Fuji 800 Press film, 30-second exposure)

► On the night of November 18, astronomers around the world were out in force, waiting for the king of all meteor showers, the Leonids, to start its show. The members of our local astronomy club, called the Sirius Lookers, were no exception. We planned on hosting a meteor shower party near our small city in northern Arizona, Sedona, which is an excellent location for stargazing. Although our club is small, we are dedicated skygazers, and we had long been looking forward to this night.

An article that appeared in our local newspaper informing the public about the Leonids inspired about 35 people to come to our gathering, eight miles outside of Sedona. Early in the evening, threatening cirrus clouds greeted us. But by 2 A.M., the clouds were breaking apart, just in time for the peak. We had already seen two bright meteors streak across the sky, giving us hope for a good night. And sure enough, by 2:30 A.M. we could no longer keep up with the number of meteors flashing overhead. At times, we counted 20 per minute, but with clouds covering about 25 percent of the sky we estimated the actual count to be around 25 to 30 meteors per minute. We even saw a number of shooting stars light up the clouds overhead. It was such a joy to finally be in the midst of a meteor storm, and I was delighted to share the experience with good friends.

Around 5:15 A.M., tired from two consecutive nights of meteor watching, a friend and I decided to head back home. But halfway there, I got a sudden gut feeling that I should capture this momentous event on film, as up to this point I had simply been enjoying the show without worrying about taking pictures. As soon as I got home, I grabbed my camera and tripod and headed to a popular site in Sedona called Bell Rock. By now, it was 5:45 A.M. and I knew that daylight was only minutes away. I set up the camera quickly and shot my first long exposure. When I had finished setting up my second shot, out of the corner of my eye I noticed something very bright lighting up the northern part of the sky. I quickly clicked the release cable, hoping I didn't shake it as I did so. The visual turned out to be absolutely stunning — it was the brightest meteor I have ever seen in 25 years of skywatching. The meteor appeared many times brighter than the full moon and had a distinct blue-green color.

The night was an experience I'll never forget. ◼

Dennis Young is an avid amateur astronomer and astro-scenic photographer.

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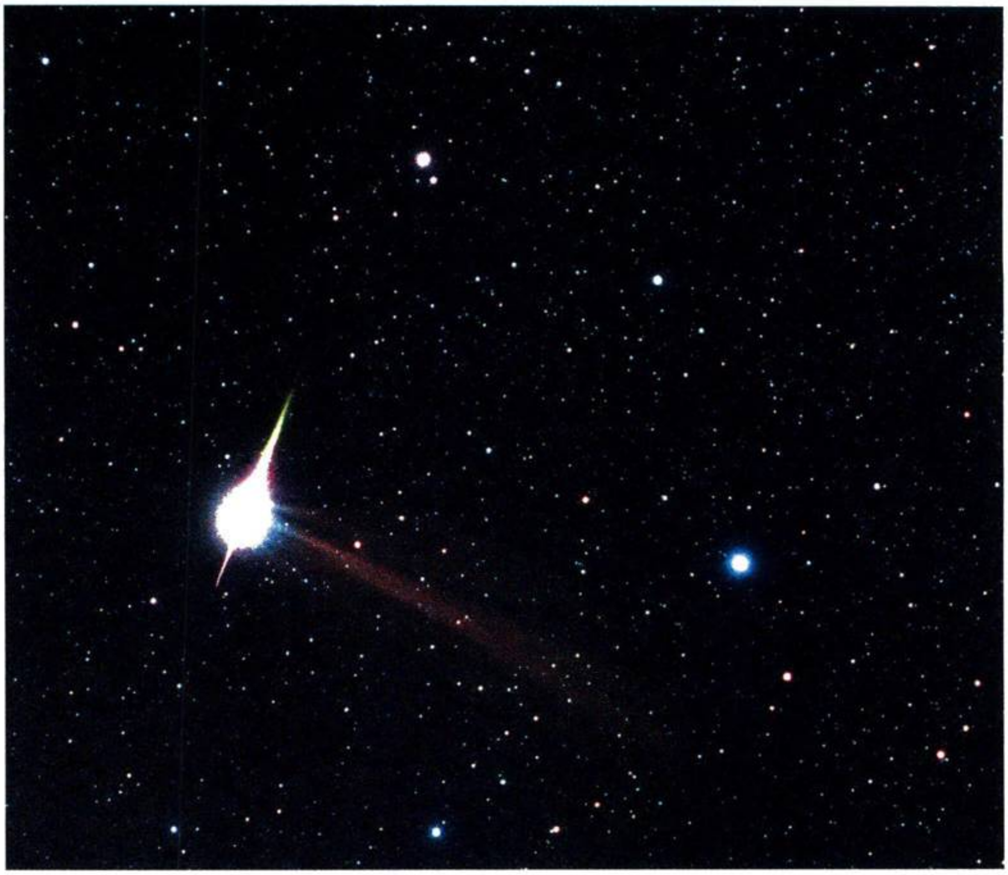
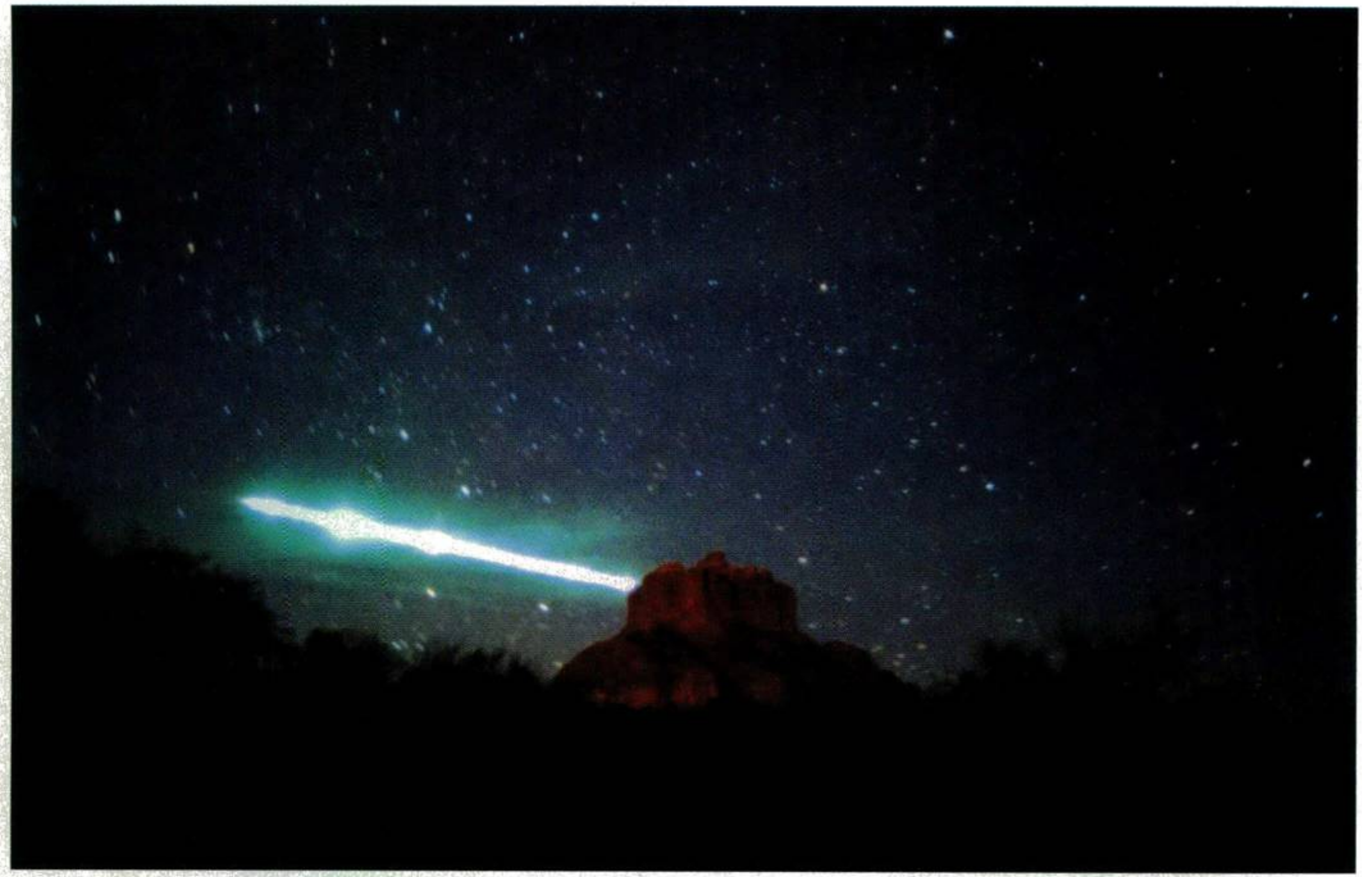
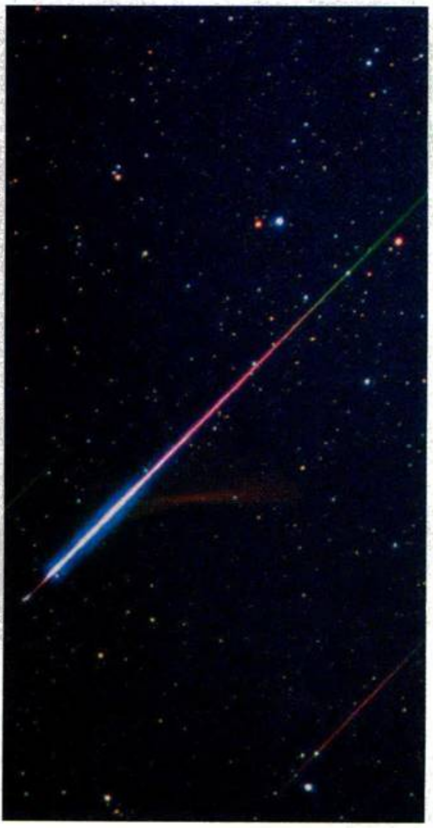


Leonid Fireball
DENNIS MAMMANA
(50mm lens at f/2.4, Kodak P-1600 film, 4-minute exposure)

Leonid over Mt. Etna, Sicily
GIANNI TUMINO AND MELANIA PLUCHINOTTA
(28mm lens at f/2.8, Kodak Ektachrome 200 film, 10-minute exposure)





Fireball over Bell Rock, Sedona, Arizona

DENNIS YOUNG

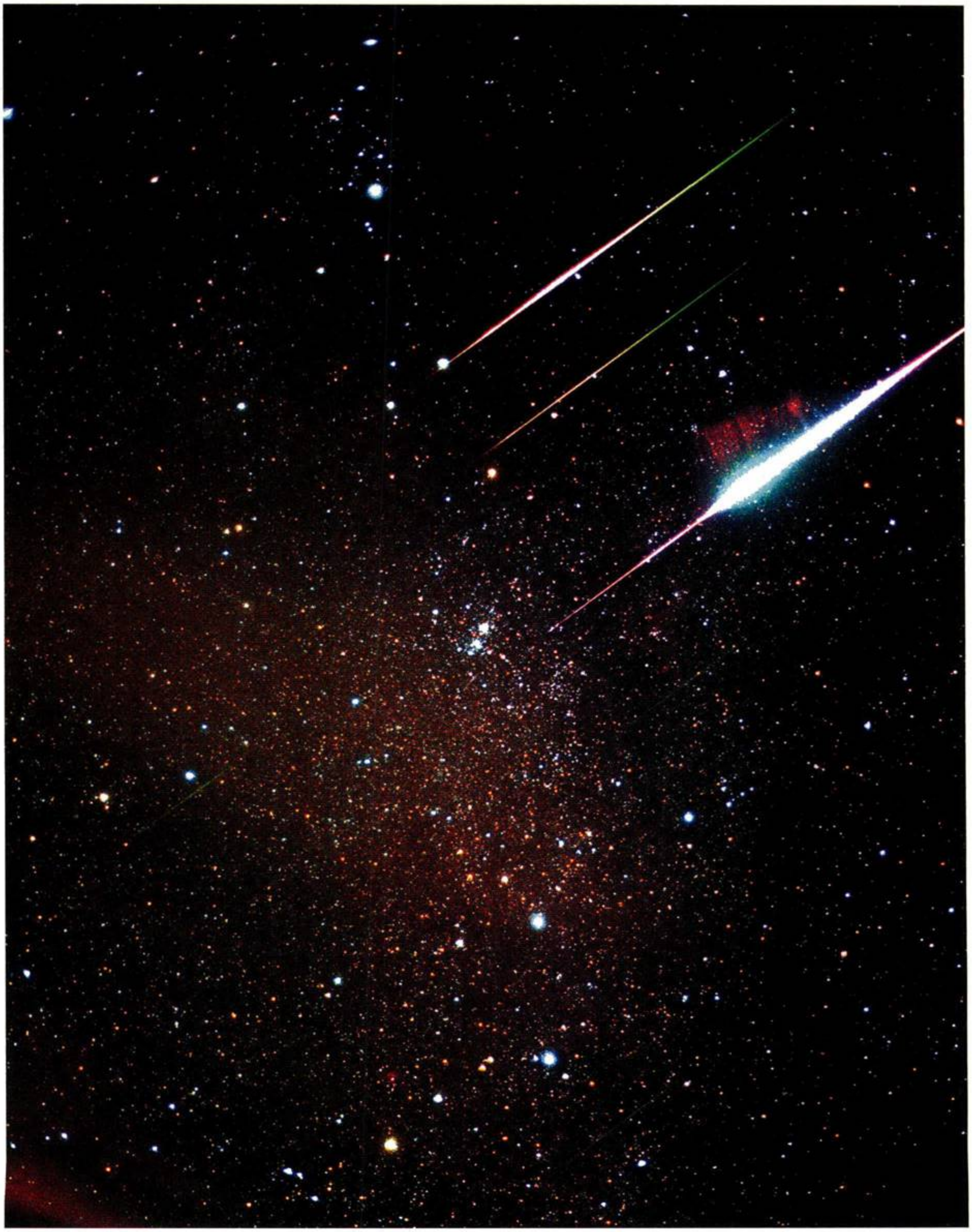
(28mm lens at f/2, Kodak 400 ISO film, 2 ½-minute exposure)

Leonid Fireball and Smoke Trail

JERRY LODRIGUSS

(85mm lens at f/2, Fuji 800 film, 5-minute exposure)

This month's best astrophoto



Leonid Meteor Composite

STEPHEN PITT

(35mm lens at f/2.8, composite of two 6-minute exposures)

This stunning photo was created by combining two images taken over Joshua Tree National Park, California.

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* Patent pending

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